SCIENCE

17 July 1959

Volume 130, Number 3368

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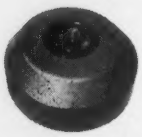

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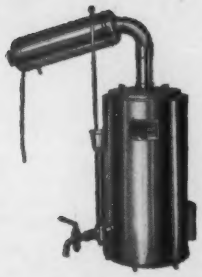

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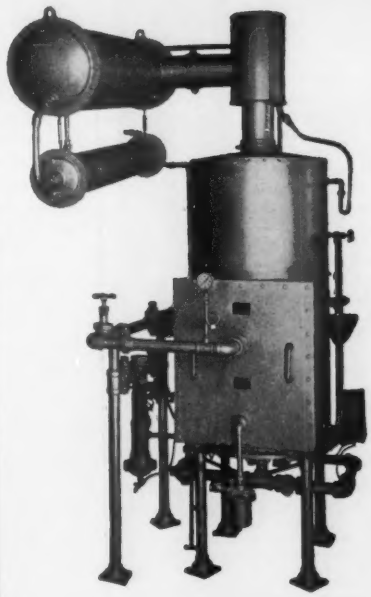

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Letters

Studies of Fallout

The article relative to radiation hazards and Government [*Science* **129**, 1210 (1959)] impressed me as a fair, sound, and useful statement of the problem. I am sorry, however, that Project Sunshine was written up in such a negative way. This was probably more a matter of public relations on the part of the Division of Biology and Medicine than anything else.

As the United States Representative to the United Nations Scientific Committee on the Effects of Atomic Radiation, I was impressed to learn that the United States had been able to make available a wealth of material as a result of Sunshine and related projects without which the development of our report to the General Assembly of last August would have been difficult. The material provided this committee by the United States was greater than that provided by all other countries.

It would be helpful if one thing could be made clear—the tremendous difficulty of making these analyses of almost infinitesimal amounts of material. One of the great achievements of Libby and the radiochemists, both those who are associated with him and radiochemists in general, has been the development of reliable analytical methods that have made the studies of fallout meaningful. Determinations of total beta activity as made by the Public Health Service are meaningful only in light of the ability to compare them with the more exact determinations that are made.

The Atomic Energy Commission has been active since its inception in stimulating interest and competence in the Public Health Service in the field of radiation and radiobiology. The activities of the Public Health Service mentioned in the article—operations at the Columbia River and the Robert A. Taft Sanitary Engineering Center, offsite monitoring, and the research program in radiobiology—were all stimulated by the AEC or its predecessor, the Manhattan Project.

SHIELDS WARREN
Cancer Research Institute, Boston, Massachusetts

Basic Research

Definitions of basic research [for example, C. V. Kidd, *Science* **129**, 368 (1959)] remind me of the fat and lean physicians who were asked to classify a couple of hundred patients as obese, normal, or underweight. It should come as no surprise to find that the lean physicians classified many more patients as obese than did the fat ones.

Similarly, definitions of basic research are not made by engineers, physicists, research managers, and so on—they are made by people, each with his personal packet of professional training and biases. Each such person tends, I believe, to define basic research from his own personal place in the scientific spectrum—everything on his left is basic, everything on his right, applied. Research an engineer calls basic may well be regarded as applied by a physicist.

This approach is, of course, practical nominalism, as opposed to the attitude of those who believe that if they can find the "lost chord" of magic words they can unmask a universal, essence, or concept of "basic research" good for the ages, or at least good till the next administration.

The working scientist could relegate this discussion to the metaphysicians of the philosophy department or to the front office and proceed with his business if it were not for one practical consequence. Good research proposals may find themselves wandering in a limbo between fund-granting agencies—too basic for the hard-bitten practical men of one, too applied for the purists of another. Good will on both sides can, and does, solve such problems, but beware of Aristotelian classifications in the non-Aristotelian world of science.

HAROLD WOOSTER
2108 Seminary Road, Silver Spring, Maryland

Basic Research in Europe

In the interesting survey article entitled "Basic research in Europe" [*Science* **128**, 227 (1958)], written by David M. Gates, the author refers to the state of North Westphalia, which at the present time does not exist. Probably the author had the state of North Rhin-Westphalia in mind instead.

It is also stated that research funds in Spain "are controlled largely through the Superior Council for Scientific Research, under the Ministry of Education, and are distributed to academic institutes in all fields of science, *except agriculture*" (italics mine). This statement shows unfortunate misinformation on the part of the author. The "Misión-Biológica de Galicia" has been engaged in agricultural research since 1921. That institution has been absorbed by the Superior Council for Scientific Research, which at the same time supports agricultural research in institutes and experimental stations in localities such as Madrid, Sevilla, Granada, Murcia, Salamanca, and Santiago de Compostela, among others.

Another obvious piece of misinforma-

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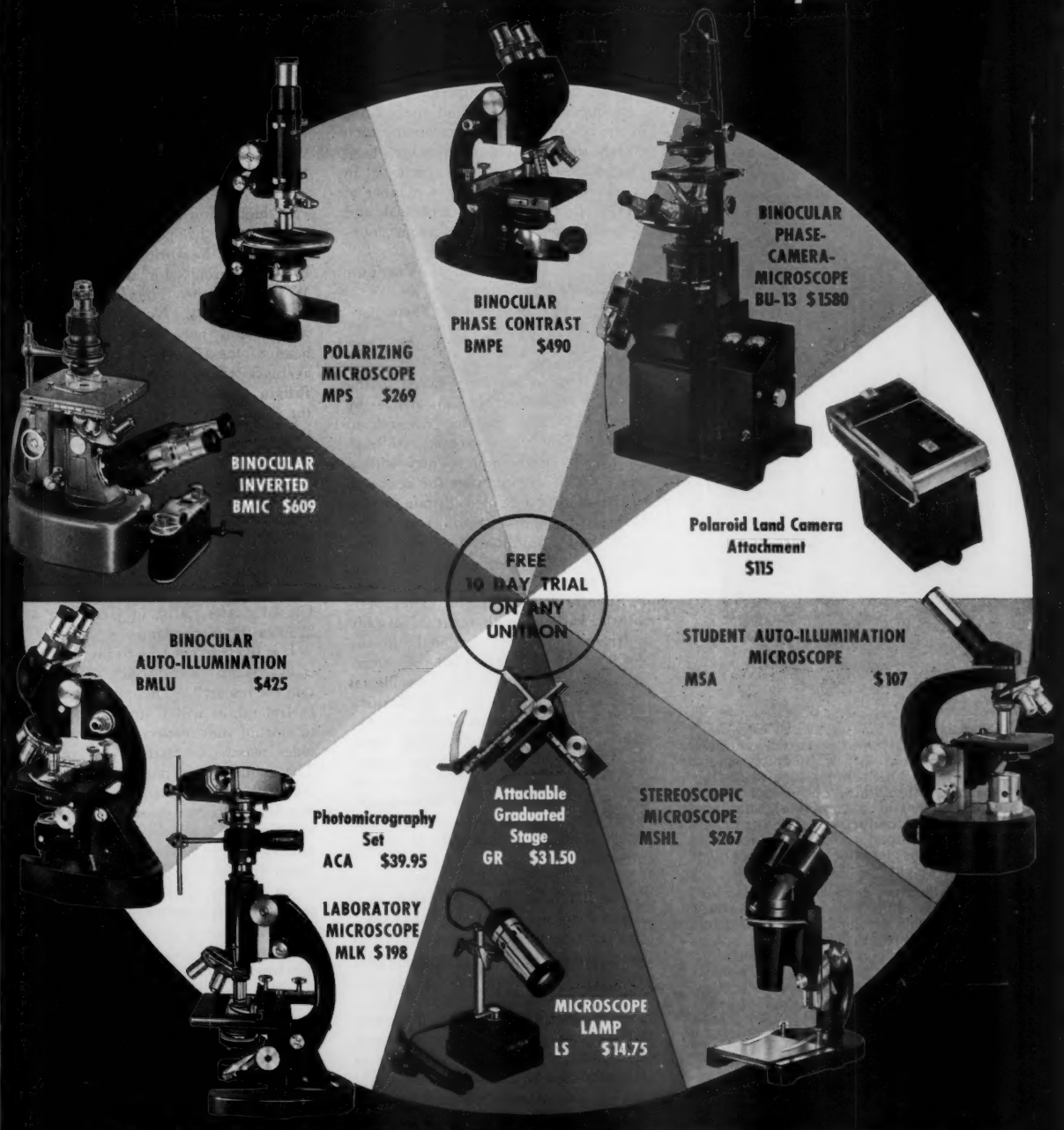

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tion given in the article is that "in Portugal [there is] far greater freedom and communication with the outside than will ever be possible under the present regime in Spain." The international activities of the Superior Council for Scientific Research are summarized in a booklet entitled "Actividades Internacionales del Consejo Superior de Investigaciones Cientificas," and the catalog of the research staff of that organization clearly shows that most members have had extensive research experience in other countries. At present a number of private firms also have technical and scientific exchange with foreign countries.

A. G. VERDUCH
Instituto de Edafologia y Fisiologia Vegetal, Madrid, Spain

My attention has been called to the following statement in an article by David M. Gates on basic research in Europe: "Eire is an overpopulated, tragically poor agricultural country with a total lack of organization for research. In the shadow of Great Britain it is a little surprising that more cross fertilization and inspiration have not taken place."

The factual statements in the foregoing paragraph are, I regret to say, seriously at variance with reality. Not only is Ireland not "overpopulated" in the normal sense of the term but the reverse is the case, as a glance at the table on population density in the *U.N. Statistical Year Book* of 1956 (pages 32–34) will amply demonstrate. That table shows that in 1955, whereas the density of population per square kilometer was of the order of 331 in the Netherlands, 291 in Belgium, 121 in Switzerland, and 103 in Denmark, it was only 41 in Ireland.

To speak of Ireland as a "tragically poor agricultural country" is likewise a serious exaggeration. For many reasons, some of which derive from historical causes, Ireland is not as prosperous as it might have been under different circumstances. However, since the establishment of an independent state a generation ago, considerable effort has been made both to raise the general level of prosperity and to correct the disequilibrium in the economy which resulted from the enforced subservience over a long period of time of the Irish economy to that of Britain. Although the process is inevitably a slow one, these efforts have already achieved some success; the value of the contribution of nonagricultural activities to the national income rose from $337 million in 1938 to $924 million in 1957. During this period the number of persons engaged in industry rose by 30 percent, while at the same time output per head in the agricultural sector increased by 65 percent. In 1930 we produced 60 million units of electricity; last year we produced 1860 million units and distributed it not only in urban areas but to 240,000 rural homes and workshops.

Furthermore, Ireland cannot be held to be a poor country in the ordinary connotation of the term. It is true that, by comparison with other countries of Western Europe (one of the most highly developed economic areas of the world), the standard of living—as judged, for instance, by income per head—is not very high. However, it is certainly not low, either, by comparison with the countries of the world generally, or even by comparison with the countries of Western Europe. The *U.N. Statistical Papers* series E, No. 4, for instance, which show net national product per head at factor cost in U.S. dollars as averages for the years 1952–54, give for Britain a figure of 780; Germany, 510; the Netherlands, 500; Ireland, 410; Austria, 370; Italy, 310; Greece, 220; and Portugal, 200. Furthermore, food consumption per head in Ireland is among the highest in the world. The *OEEC General Statistics* (1958, No. 6) show that in terms of calories per day such consumption in Ireland for the year July 1956–July 1957 stood at 3550 as compared with 3240 in Britain, 3220 in the United States, 3010 in Germany, and 2930 in the Netherlands.

It is likewise not true to say that there is in Ireland "a total lack of organization for research." The university system in Ireland, as will I am sure be known to most of your readers, is good and provides reasonable facilities for research. The country does not, of course, command the same financial resources in this field as bigger countries which have had time to develop their economic resources. But to give the impression, as Gates does, that Ireland is, in this field, in an entirely backward situation is a gross misrepresentation.

JOHN J. HEARNE, *Ambassador*
Embassy of Ireland, Washington, D.C.

The article entitled "Basic research in Europe," by D. M. Gates, assistant division chief of the Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado, who was attached to the London branch of the Office of Naval Research from 1955 to 1957, contains the following reference to my country: "Eire is an overpopulated, tragically poor agricultural country with a total lack of organization for research. In the shadow of Great Britain it is a little surprising that more cross fertilization and inspiration have not taken place."

(*Continued on page 168*)

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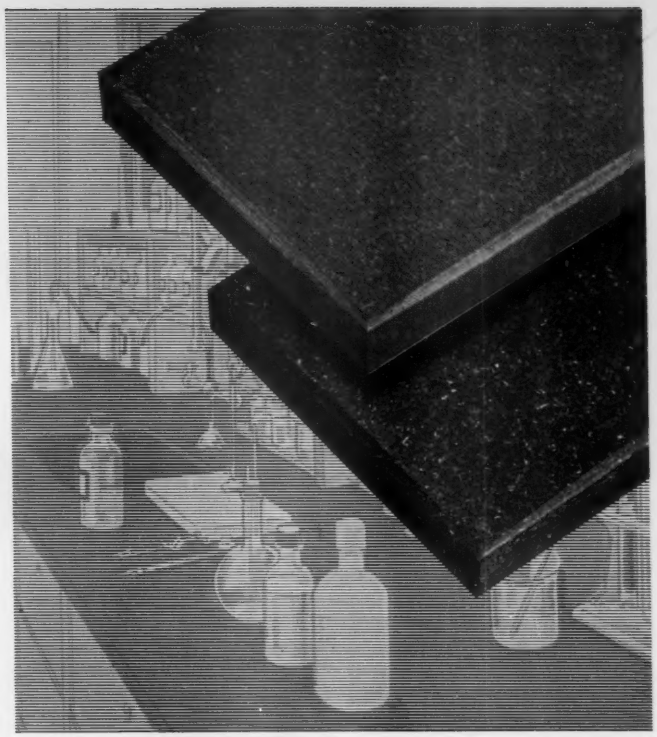

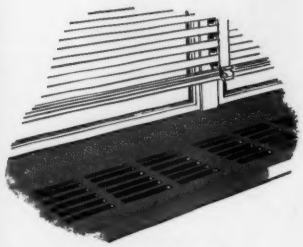

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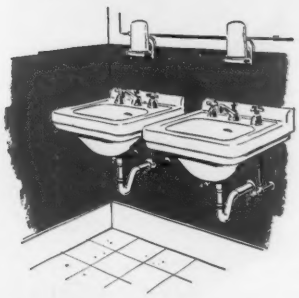

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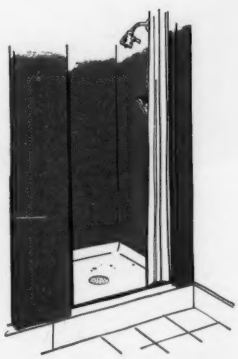

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Michael Faraday...on self-criticism

"The philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a respecter of persons but of things. Truth should be his primary object. If to these qualities be added industry he may indeed go and hope to walk within the veil of the temple of Nature."

—Quoted in Sir Richard Gregory, *Discovery*

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Dog Days

Local attitudes toward the weather are almost as varied as the weather itself. Pride in climate takes two predominant forms. If the climate in a certain region is reputed to be pleasant, the natives take a defensive pride in it. If a visitor to northern California feels uncomfortably hot, he will be told that it is not as hot as he thinks it is, that anyway it is a dry heat and less distressing than it would be where he came from, and that besides it is a very unusual day.

If, on the contrary, the local summer climate is generally thought to be hot or muggy, the natives have a different kind of pride—pride of survival. If a visitor to a city on the eastern seaboard finds himself gasping and mopping his brow, a native will indicate that the day is really unusually good for this time of year, and he may add smugly, "You ain't seen nothing yet!"

In a program begun experimentally on 1 June in a few large cities, the U.S. Weather Bureau provided a new set of figures for the weather *aficionados* to ponder, a "Discomfort Index." This index takes both temperature and humidity into account in attempting to estimate human reaction to the weather. The index has been devised in such a way that the resulting figures lie within the familiar range of ordinary temperatures on the Fahrenheit scale. It is simple to calculate: add the dry- and wet-bulb temperatures, multiply the sum by 0.4, and add 15. A D.I. of 75 would, for example, result from dry- and wet-bulb readings of 78° and 72° or 85° and 65° or 92° and 63°. The bureau estimates that some people feel uncomfortable at a D.I. of 70; that more than half feel uncomfortable at 75; and that virtually everyone feels uncomfortable, if not acutely miserable, at 80.

The index is of more than conversational interest. In cities where air conditioning is widely used, the index is more closely correlated with the power demands than is temperature alone. Consequently, the index should serve as a good predictor of peak loads for public utilities.

Some characteristic average D.I.'s for local noon during July and August are as follows: 64, San Francisco; 65, Seattle; 71, Denver; 73, New York, Philadelphia, Chicago, Los Angeles; 76, Washington, Baltimore; 78, St. Louis; 80, Miami, New Orleans; 81, Tampa, Key West. The bureau has also estimated some recent record highs (dry-bulb temperatures in parentheses); 92, Yuma (119°); 89, Kansas City (112°); 85, New Orleans (96°); 84, Chicago (100°).

But if the ordinary citizen in less favored regions takes pleasure in reminiscing about past hardships and contemplates with relish forthcoming tests of his physiological adaptability, merchants, other than those who purvey Good Humors, air conditioners, and so on, do not. The publication of the index stirred up a storm of a kind with which the Weather Bureau is unfamiliar. Boards of trade and some retailers cried out in anguish that such predictions would be bad for business, and the bureau beat a hasty retreat. *Discomfort Index* metamorphosed into *Temperature-Humidity Index* and all is well, except for the fact that the bureau would like a better name than this.

The following are among those that have been suggested: Comfort Index, Temp-Hum Index, Thermidity Scale, Misery Meter, Atmosfactor, Comfort-Table, Holiday Index, Thermosation Scale, and Toler-Rate.

What is wanted is a good descriptive word with pleasant overtones. Any suggestions?—G. DuS.

17 July 1959, Volume 130, Number 3368 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Imprinting

An effect of early experience, imprinting determines later social behavior in animals.

Eckhard H. Hess

Students of behavior generally agree that the early experiences of animals (including man) have a profound effect on their adult behavior. Some psychologists go so far as to state that the effect of early experience upon adult behavior is inversely correlated with age. This may be an oversimplification, but in general it appears to hold true. Thus, the problem of the investigator is not so much to find out *whether* early experience determines adult behavior as to discover *how* it determines adult behavior.

Three statements are usually made about the effects of early experience. The first is that early habits are very persistent and may prevent the formation of new ones. This, of course, refers not only to the experimental study of animals but also to the rearing of children. The second statement is that early perceptions deeply affect all future learning. This concept leads to the difficult question whether basic perceptions—the way we have of seeing the world about us—are inherited or acquired. The third statement is simply that early social contacts determine the character of adult social behavior. This is the phenomenon of imprinting.

At the turn of the century, Craig (*1*), experimenting with wild pigeons, found that in order to cross two different species it was first necessary to rear the young of one species under the adults of the other. Upon reaching maturity the birds so reared preferred mates of the same species as their foster parents. Other interspecies sexual fixations have been observed in birds and fishes.

Heinroth (*2, 3*) and his wife successfully reared by hand the young of almost every species of European birds. They found that many of the social responses of these birds were transferred to their human caretaker. Lorenz (*4*) extended these experiments, dealing especially with greylag geese.

Lorenz was the first to call this phenomenon "imprinting," although earlier workers had observed this effect. He was also the first to point out that it appeared to occur at a critical period early in the life of an animal. He postulated that the first object to elicit a social response later released not only that response but also related responses such as sexual behavior. Imprinting, then, was related not only to the problem of behavior but also to the general biological problem of evolution and speciation.

Although imprinting has been studied mainly in birds, it also has been observed to occur in other animals. Instances of imprinting have been reported in insects (*5*), in fish (*6*), and in some mammals. Those mammals in which the phenomenon has been found —sheep (*7*), deer (*8*), and buffalo (*8a*) —are all animals in which the young are mobile almost immediately after birth. Controlled experimental work with mammals, however, has just begun.

The first systematic investigations of imprinting were published in 1951. Simultaneously in this country and in Europe, the work of Ramsay (*9*) and Fabricius (*10*) gave the first indication of some of the important variables of the process. Ramsay worked with several species of ducks and a variety of breeds of chickens. He noticed the importance of the auditory component in the imprinting experiment and the effect of changes in coloring on parental recognition as well as on recognition of the parents by the young. His findings also showed that color is an essential element in recognition, while size or form seemed to be of less importance. Most of Ramsay's experiments dealt with exchange of parents and young and did not involve the use of models or decoys as imprinting objects, although he also imprinted some waterfowl on such objects as a football or a green box.

Fabricius carried on experiments with several species of ducklings and was able to determine approximately the critical age at which imprinting was most successful in several species of ducks. In some laboratory experiments he found it impossible to do imprinting in ducklings with a silent decoy—something which my coworkers and I were easily able to do a few years later in our Maryland laboratory. After the appearance of this pioneer work by Ramsay and by Fabricius, no relevant papers appeared until 1954. At that time Ramsay and Hess (*11*) published a paper on a laboratory approach to the study of imprinting. The basic technique was modified slightly the following year and then was continued in the form described below. Papers in 1956 by Margaret Nice (*12*) and by Hinde, Thorpe, and Vince (*13*) include most of the pertinent materials published up to 1956 since Lorenz's classic statement of the problem.

Since 1956, however, there has been an increasing number of papers on imprinting in a variety of journals. However, most investigators report experiments which are primarily designed to look for ways in which imprinting can be likened to associative learning and are not primarily carried out to investigate the phenomenon itself. Later we

The author is on the staff of the department of psychology, University of Chicago, Chicago, Ill.

shall return to a consideration of these experiments; for the present we shall concern ourselves mainly with the program carried out since 1951 at McDonogh and at Lake Farm Laboratory, Maryland, and at our laboratories at the University of Chicago (*14*).

Experimental Studies

Our laboratory in Maryland had access to a small duck pond in which we kept relatively wild mallards. The birds laid their eggs in nesting boxes, so the eggs could be collected regularly. After storage for a few days, the eggs were incubated in a dark, forced-air incubator. About two days before hatching, the eggs were transferred to a hatching incubator. Precautions were taken to place the newly hatched bird into a small cardboard box (5 by 4 by 4 inches) in such a way that it could see very little in the dim light used to carry out the procedure.

Each bird was given a number, which was recorded on the box itself as well as in our permanent records. The box containing the bird was then placed in a still-air incubator, used as a brooder, and kept there until the bird was to be imprinted. After the young bird had undergone the imprinting procedure, it was automatically returned to the box, and the box was then transferred to a fourth incubator, also used as a brooder, and kept there until the bird was to be tested. Only after testing was completed was the duckling placed in daylight and given food and water.

The apparatus we constructed to be used in the imprinting procedure consisted of a circular runway about 5 feet in diameter. This runway was 12 inches wide and 12½ feet in circumference at the center. Boundaries were formed by walls of Plexiglas 12 inches high. A mallard duck decoy, suspended from an elevated arm radiating from the center of the apparatus, was fitted internally with a loud-speaker and a heating element. It was held about 2 inches above the center of the runway. The arms suspending the decoy could be rotated by either of two variable-speed motors. The speed of rotating and intermittent movement could be regulated from the control panel located behind a one-way screen about 5 feet from the apparatus. The number of rotations of both the decoy and the animal were recorded automatically. Tape recorders with continuous tapes provided the sound that was played through the speaker inside the decoy. A trap door in the runway, operated from the control panel, returned the duckling to its box.

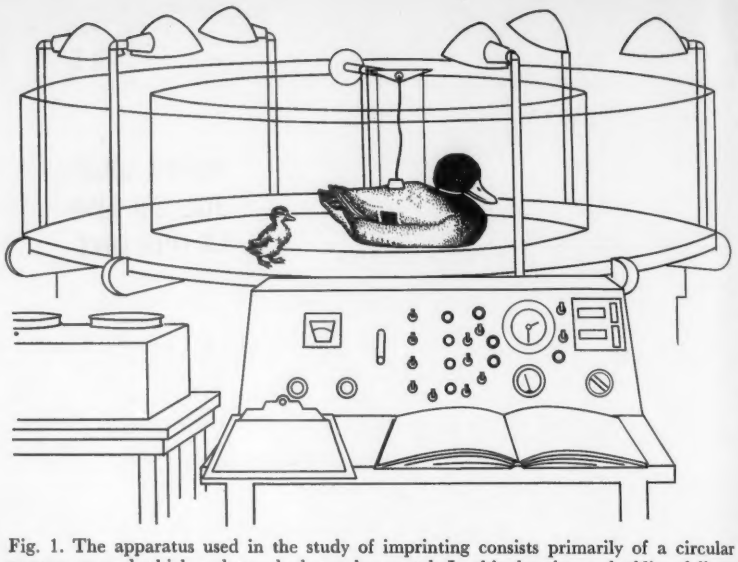


Fig. 1. The apparatus used in the study of imprinting consists primarily of a circular runway around which a decoy duck can be moved. In this drawing a duckling follows the decoy. The controls of the apparatus are in the foreground.

Imprinting procedure. The young mallard, at a certain number of hours after hatching, was taken in its box from the incubator and placed in the runway of the apparatus (Fig. 1). The decoy at this time was situated about 1 foot away. By means of a cord, pulley, and clip arrangement, the observer released the bird and removed the box. As the bird was released, the sound was turned on in the decoy model, and after a short interval the decoy began to move about the circular runway. The sound we used in the imprinting of the mallard ducklings was an arbitrarily chosen human rendition of *"gock,* gock, gock, gock, gock." The decoy emitted this call continually during the imprinting process. The duckling was allowed to remain in the apparatus for a specified amount of time while making a certain number of turns in the runway. At the end of the imprinting period, which was usually less than 1 hour, the duckling was automatically returned to its box and placed in an incubator until it was tested for imprinting strength at a later hour.

Testing for imprinting. Each duckling to be tested was mechanically released from its box halfway between two duck models placed 4 feet apart. One of these was the male mallard model upon which it had been imprinted; the other was a female model which differed from the male only in its coloration. One minute was allowed for the duckling to make a decisive response to the silent models. At the end of this time, regardless of the nature of the duckling's response, sound was turned on simultaneously for each of the models. The male model made the "gock" call upon which the duckling had been imprinted, while the female model gave the call of a real mallard female calling her young.

Four test conditions followed each other in immediate succession in the testing procedure. They were: (i) both models stationary and silent; (ii) both models stationary and calling; (iii) the male stationary and the female calling; (iv) the male stationary and silent and the female moving and calling. We estimated these four tests to be in order of increasing difficulty. The time of response and the character of the call note (pleasure tones or distress notes) were recorded. Scores in percentage of positive responses were then recorded for each animal. If the duckling gave a positive response to the imprinting object (the male decoy) in all four tests, imprinting was regarded as complete, or 100 percent.

Determination of the "Critical Period"

To determine the age at which an imprinting experience was most effective we imprinted our ducklings at various ages after hatching. In this series of ex-

periments the imprinting experience was standard. It consisted in having the duckling follow the model 150 to 200 feet around the runway during a period of 10 minutes. Figure 2 shows the scores made by ducklings in the different age groups. It appears that some imprinting occurs immediately after hatching, but a maximum score is consistently made only by those ducklings imprinted in the 13- to 16-hour-old group. This result is indicated in Fig. 3, which shows the percentage of animals in each age group that made perfect imprinting scores.

Social facilitation in imprinting. In order to find whether imprinting would occur in those ducklings which were past the critical age for imprinting—that is, over 24 hours of age—we attempted to imprint these older ducklings in the presence of another duckling which had received an intensive imprinting experience. Ducklings ranging in age from 24 to 52 hours were given 100 feet of following experience during a period of 30 minutes. The average score for the ducklings was 50 percent; this shows that some imprinting can occur as a result of social facilitation. Two conclusions can be drawn. (i) Social facilitation will extend the critical age for imprinting. (ii) The strength of imprinting in these older ducklings is significantly less than that when the animal is imprinted alone at the critical age under the same time and distance conditions; under the latter circumstances the average score made is between 80 and 90 percent. A further indication of this dissipation of imprintability with increasing age is obtained when we average the scores for those animals which were between 24 and 32 hours old. The average score for these animals was 60 percent, while the score made by older animals ranging in age from 36 to 52 hours was 43 percent. One last item points to the difference; even when the time and distance were increased during imprinting of the older ducklings there were no perfect scores. With such a large amount of distance to travel during the imprinting period, approximately 40 percent of the animals would be expected to make perfect scores if they were imprinted during the critical period.

Field Tests of Imprinting

In this same exploratory vein we have also carried out some studies under more normal environmental conditions. To do this we took animals imprinted in our apparatus and placed them in the duck-pond area, where they could either stay near a model placed at the water's edge or follow the model as it was moved along the surface of the duck pond, or go to real mallards which had just hatched their ducklings. Imprinted ducklings did not follow the live mallard females who had young of an age similar to that of the experimental animals. In fact, they avoided her and moved even closer to the decoy. Naive mallards, about a day old, from our incubator, immediately joined such live females and paid no attention to the decoys. These records, which we captured on motion-picture film, offer proof that what we do in the laboratory is quite relevant to the normal behavior of the animals and is not a laboratory artifact.

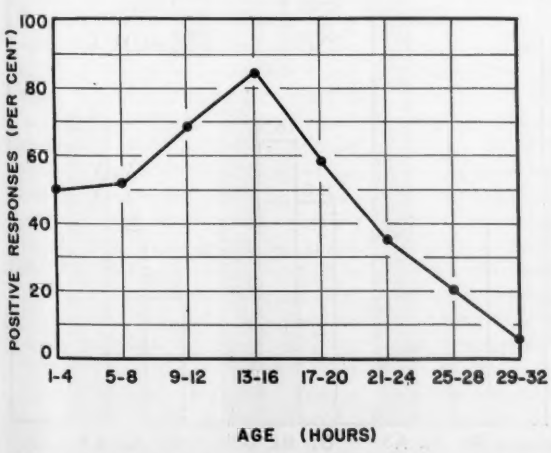
Color and Form Preferences in Imprinting Objects

An examination of the importance of the form and color of an imprinting object is relevant to any inquiry concerning factors contributing to the strength of imprinting (*15*).

Eight spheres approximately 7 inches in diameter in the colors red, orange, yellow, green, and blue, and in achromatic shades of near-black, near-white, and neutral grey were presented to 95 young Vantress broiler chicks as imprinting objects. The imprinting procedure was essentially the same as that described above in the duckling experiments. All the animals were exposed to one of the spheres during the critical period. Each imprinting experience lasted for a total of 17 minutes, during which time the imprinting object moved a distance of 40 feet.

Twenty-four hours after imprinting, each animal was tested in a situation where the object to which it had been imprinted was presented, together with the remaining four colored spheres if the animal had been imprinted to a colored sphere, or with the remaining two achromatic spheres, if the animal had been imprinted to one of the achromatic spheres.

It was found that the stimuli differed significantly in the degree to which they elicited the following-reaction. The stimuli, ranked in their effectiveness for eliciting following during imprinting, from the highest to the lowest, are: blue, red, green, orange, grey, black, yellow, white. These colors, in the same order, were increasingly less



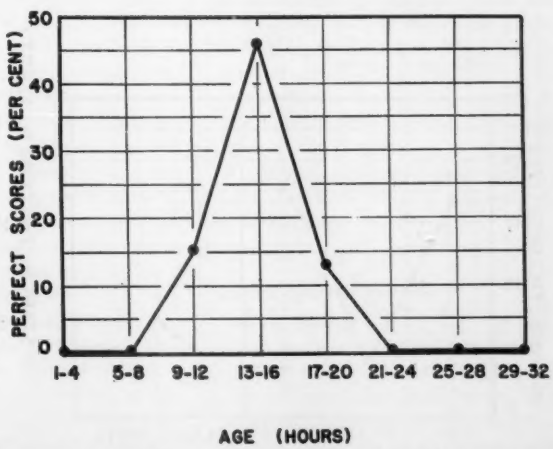


Fig. 2 (left). The critical age at which ducklings are most effectively imprinted is depicted by this curve, which shows the average test score of ducklings imprinted at each age group. Fig. 3 (right). Another way of showing the critical age is by plotting the percentage of animals in each age group that made scores of 100 percent in testing.

effective in terms of the scores made during the testing period. We concluded from this that the coloring of a stimulus is more important than its reflectance.

In order to determine also form preferences in imprinting objects, we took the same spheres we used in determining color preferences and added superstructures of the same coloring, so that the spheres had heads, wings, and tails (Figs. 4 and 5).

The addition of superstructures had a definite effect on the ease with which the following-reaction could be elicited: the plain ball was found to be the most efficient; the ball with wing and tail-like superstructures, less so; and the ball to which wings, tail, and head had been added, least efficient. We even presented a stuffed brown Leghorn rooster to the chicks, and it was found to be the least efficient model of all in eliciting the following response.

Auditory Imprinting in the Egg

Some investigators of imprinting have felt that vocalization of the incubating parent might cause imprinting to that vocalization even before the young fowl hatched. This seemed a likely hypothesis, so we carried out the following experiment. About 30 mallard eggs were incubated in an incubator with a built-in loud-speaker. For 48 hours before hatching these mallards were exposed to a constantly played taped recording of a female mallard calling her young. Eggs were removed just before hatching and placed in a different incubator. Later, when tested, these young made no significantly greater choice of this source of sound than of the "gock" call used in our normal imprinting procedure. [A preliminary experiment was reported earlier (*11*).] Auditory imprinting, while the mallard is still in the egg, is therefore considered to be unlikely.

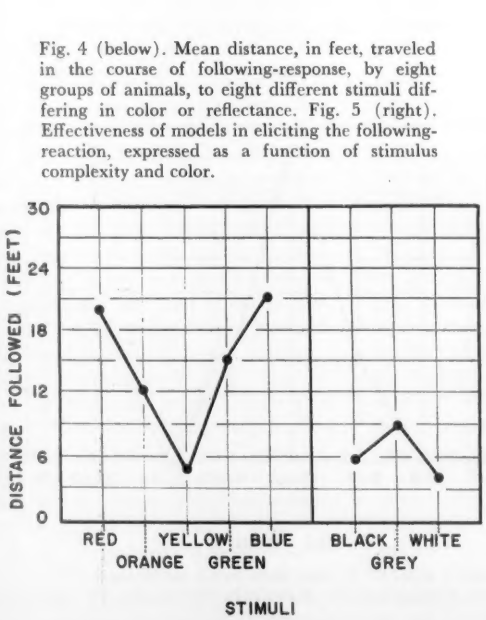
Law of Effort

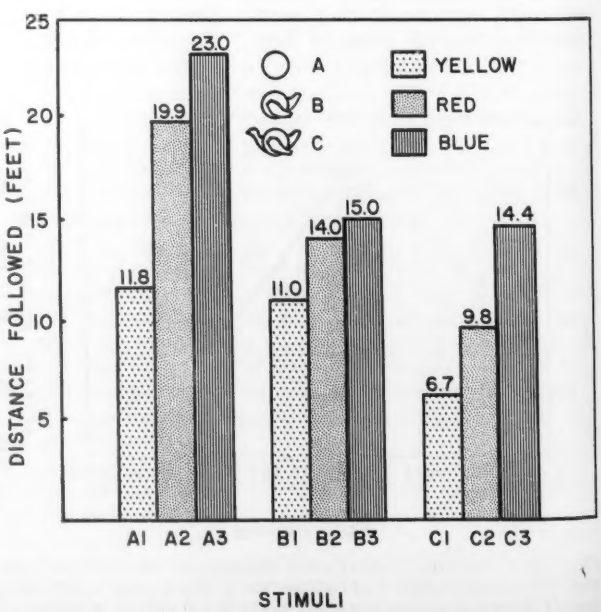
We decided to vary independently the factors of time of exposure and the actual distance traveled by the duckling during the imprinting period. Since previous results had indicated that a 10-minute exposure period was sufficient to produce testable results, we decided to run a series of animals, varying the distance traveled but keeping the time constant at 10 minutes. We therefore used one circumference of the runway (12½ feet) as a unit and ran groups of animals for zero, one, two, four, and eight turns. This resulted in imprinting experiences in which the ducklings moved about 1 foot, 12½ feet, 25 feet, 50 feet, and 100 feet, respectively. All ducklings were imprinted when they were between 12 and 17 hours of age, in order to keep the variable of critical period constant. The results showed that increasing the distance over which the duckling had to follow the imprinting object increased the strength of imprinting. A leveling-off of this effect appears to occur after a distance of about 50 feet. These results are shown in Fig. 6.

In order to determine the effect of length of exposure time on imprinting strength, we chose a distance that could be traversed by ducklings in periods of time as short as 2, 10, and 30 minutes. The scores made by animals imprinted for 2, 10, and 30 minutes, respectively, while traveling a distance of 12½ feet were essentially identical. Moreover, there is no significant difference between the findings for ducklings allowed to follow for a distance of 100 feet during a 10-minute period and those allowed 30 minutes to cover the same distance. These results are shown in Fig. 7.

The strength of imprinting appeared to be dependent not on the duration of the imprinting period but on the effort exerted by the duckling in following the imprinting object. To confirm this notion we tried two supplementary experiments (*16*). In the first, we placed 4-inch hurdles in the runway so that the ducklings not only had to follow the model but also had to clear the obstacles. As we suspected, the birds which had to climb the hurdles, and thus ex-

Fig. 4 (below). Mean distance, in feet, traveled in the course of following-response, by eight groups of animals, to eight different stimuli differing in color or reflectance. Fig. 5 (right). Effectiveness of models in eliciting the following-reaction, expressed as a function of stimulus complexity and color.





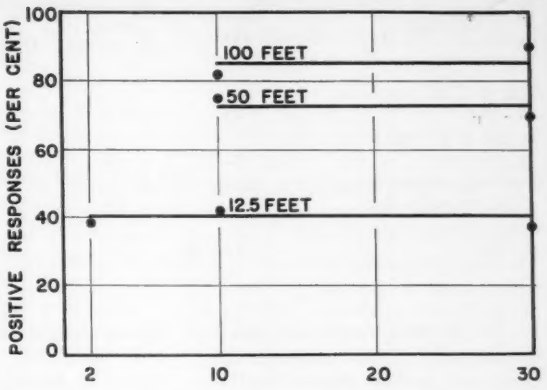


Fig. 6 (left). Strength of imprinting as a function of distance traveled by ducklings, with exposure time held constant. Fig. 7 (right). Strength of imprinting as a function of duration and exposure in minutes. Time had little effect on the test scores of the ducklings when the distance traveled was held constant.

pend more effort, made higher imprinting scores than those which traveled the same distance without obstacles. In the second experiment we allowed the duckling to follow the decoy up an inclined plane, with similar results. After further experiments we came to the conclusion that we could write a formula for imprinting: the strength of imprinting equals the logarithm of the effort expended by the animal to get to the imprinting object during the imprinting period, or $I_s = \log E$.

Previous accounts in the literature on imprinting have made the following of a moving object a necessary condition of imprinting. Our results, as formulated in the law of effort, indicate that the amount of walking done by the animal during the imprinting period is of primary significance. The following experiment was therefore carried out. Two identical decoys were spaced 3 feet apart. A light over each decoy could be turned on and off so that only the model giving the "gock" call was illuminated in the darkened experimental apparatus, and the illumination was made to coincide with the call. When the duckling reached the lighted and calling model, the light and sound were turned off in that model and turned on in the other, which was 3 feet away. In this manner we could shuttle the animal back and forth and have it cover a distance similar to that used in the normal imprinting situation, where it walks behind a moving object.

Animals were run at four shuttles and 16 shuttles. The results show scores similar to those obtained previously for the 12½-foot and 50-foot distances (see Fig. 6). They indicate, again, that imprinting strength is a function of the distance walked by the duckling, regardless of whether or not the more complex perception of *following* a moving object is involved.

Fear Behavior and Locomotory Ability

In the light of the "critical period" results, the question arises as to what developmental changes might be taking place that would account for the limits of the critical period.

During the very early hours of their lives, animals show no fear. We conducted an experiment with 137 White Rock chicks of different ages (*17*) and found that there is no fear up to 13 to 16 hours after hatching. Afterwards, the proportion of animals from age group to age group begins gradually to increase up to the age of 33 to 36 hours, when all animals show fear. Fear responses will prevent an animal from engaging in the kind of social behavior necessary for imprinting to take place, since a fearful animal will avoid rather than follow a potential imprinting object.

On the other hand, fear behavior cannot account for the limitation of imprinting before the peak of maximum effectiveness. Since the strength of imprinting is dependent on locomotor activity, we postulated that the ability to move about might thus be an important factor. The ability to move about is a growth function and would limit the onset of the critical period. Hence, we tested 60 Vantress broiler chicks of White Rock stock of different ages to determine the development of increasing locomotor ability.

The two curves we obtained from these two experimental studies—one for increasing locomotor ability and one for increasing incidence of fear behavior with increasing age—were found to be in substantial agreement with the limits of the critical period. In fact, in plotting these two curves together, we obtained a hypothetical "critical period" for imprinting which strongly resembled the empirical one obtained for that breed.

It seems likely that all animals showing the phenomenon of imprinting will have a critical period which ends with the onset of fear. Thus, we can predict in a series of animals, knowing only the time of onset of fear, the end of imprintability for that species. Even in the human being one could thus theoretically place the end of maximum imprinting at about 5½ months, since observers have placed the onset of fear at about that time (*18*).

Innate Behavior Patterns and Imprinting

Most commonly the following-reaction to a certain model has been taken as a means of observing the progress of imprinting during the first exposure to the imprinting object and also as an indicator of the effectiveness of this exposure.

Table 1. Percentage of positive responses made by ducklings under different conditions of testing and drug administration.

Conditions	Control H_2O	Mempro-bamate (25 mg/kg)	Nem-butal (5 mg/kg)	Chlor-proma-zine (15 mg/kg)
Drug at 12 hr, imprinting at 24 hr	14	54	31	57
Drug at 12 hr, imprinting at 14–16 hr	62	8	28	63
Imprinting without drug at 16 hr, test under drug	61	65	61	58
Drug at 24 hr, imprinting at 26 hr	19	17	16	59

However, the following-reaction is always accompanied by other innate behaviors which may also be observed and recorded. For the present purpose, the emission of "distress notes" or "contentment tones," maintenance of silence, and fixation of an object were checked for individual animals for a 2-minute period at the beginning of an imprinting session (*19*).

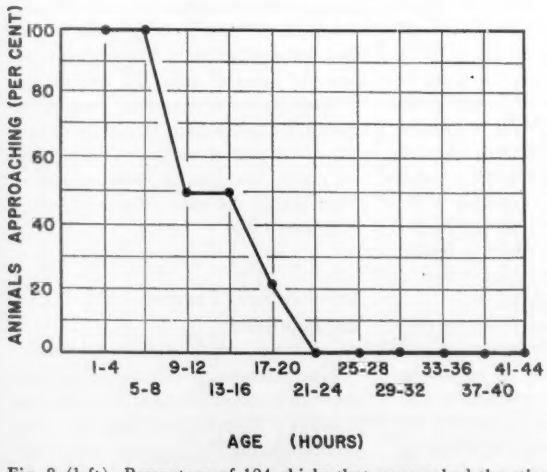
To differentiate between the "distress notes" and the "contentment tones" of chickens is comparatively easy, even for the layman who has never become familiar with them. "Distress notes" are a series of high-intensity, medium-pitch tones of approximately ¼-second duration in bursts of five to ten. Little pitch modulation occurs in this kind of call. "Contentment tones," on the other hand, are a series of high-pitch, low-intensity notes emitted in bursts of three to eight and with considerable pitch modulation during emission. The duration of the individual tones is much shorter, 1/12 of a second or less. During distress notes the animal usually holds its head high; during contentment tones it holds its head beak down. The designations *distress notes* and *contentment tones* are merely labels and should not necessarily be taken literally.

The subjects were 124 Vantress broiler chicks which had never experienced light until the time of the experiment. The experimental situation was much like the first 2 minutes of an imprinting experiment.

We found that the behavior of the animals changed markedly with age. The younger the animals were, the more pronounced was their striving to move under the cover of the nearby model. Figure 8 reflects the way in which this behavior diminished with age. Figure 9 shows that the proportion of animals fixating, or orienting toward, the model also diminished with increasing age. Although it was considerably more difficult for the younger animals to cover even the short distance between their original location and the model because of their poor locomotor ability, the time it took these younger animals to reach the model was much shorter than the time it took the older animals. However, the mode of locomotion for these younger animals was not walking but, rather, a kind of tumbling; they used both feet and wings as supports, and this left them exhausted after reaching the model a few inches away.

These results concerning behavior patterns during imprinting offer still further corroborating evidence for the location of the critical period as empirically determined. The emission of distress notes by animals older than 17 hours, even in the presence of an object that offers warmth and shelter, may be taken as an indication that a new phase of the animals' perception of their environment has set in. This behavior obstructs imprinting under the conditions of our laboratory arrangement. The high incidence of animals emitting contentment tones in the presence of the model is gradually replaced by an increasing number of animals emitting distress notes. No similar displacement occurs in animals remaining silent. The emission of contentment tones decreased as the animals became older, and the emission of distress notes increased at the same time.

The most important interpretation of these findings is that elicitation of following-behavior by various means after the critical period may not touch upon imprinting phenomena at all. Conventional training methods may be employed to overcome the fear response which the animals show after 17 hours, and it is not impossible to induce them, for example, to follow human beings. However, during the critical period, habituation or learning proper need not



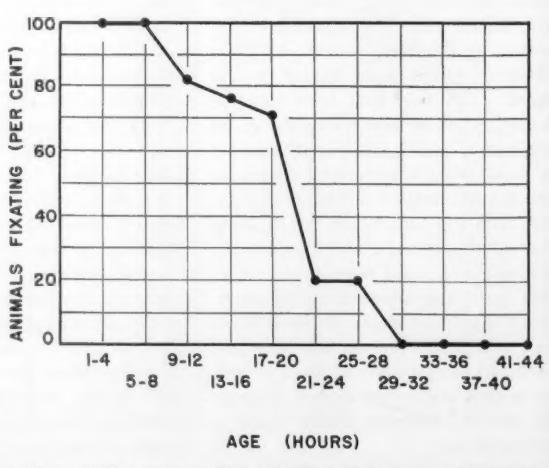


Fig. 8 (left). Percentage of 124 chicks that approached the stimulus objects at different ages. Fig. 9 (right). Percentage of 124 chicks that fixated the stimulus object at different ages.

be considered as far as lowering of fear behavior is concerned, since at that time there is little or no fear present in the animals.

Drug Studies

The rapid drop in imprinting, then, appears to be coupled with the developing emotional response of fear—a response that makes imprinting impossible. To examine this aspect of imprinting, reduction of the emotional response by means of a tranquilizing drug (*20*) seemed a logical step. Meprobamate was chosen because of evidence that it would reduce emotionality without markedly influencing motility or coordination. Preliminary experiments with dosages of meprobamate showed clearly that the emotionality of the ducklings was markedly reduced. In fact, the ducklings showed no fear of strange objects or persons, even though they were at an age where marked fear is normally a certainty.

To obtain the maximal information from this experiment, we then decided to test animals under the following four conditions: (i) drug at 12 hours of age, imprinting at 24 hours of age when the effect of the drug had worn off; (ii) drug at 12 hours of age, imprinting at 14 to 16 hours of age, test when the drug effect had worn off; (iii) imprinting at 16 hours, test under drug later; and (iv) drug at 24 hours, imprinting at 26 hours, test when the drug effect had worn off.

In general, the procedure for imprinting and testing was the same as that which has been described. Control animals were given distilled water, and chlorpromazine and Nembutal were used to obtain additional information. The results are shown in Table 1.

It is obvious that, while meprobamate reduces fear or emotional behavior, it also makes imprinting almost impossible. It does not, however, interfere with the effects of imprinting. This is clear from the results of test (iii). Chlorpromazine allows a high degree of imprinting under all conditions, whereas Nembutal reduces imprintability at all points except under the conditions of test (iii).

From the data, it appears that we might interpret the action of the drugs as follows. If we assume that meprobamate and chlorpromazine reduce metabolism, then we could expect the high imprinting scores found at 24 hours of age [test (i)], because metabolism had been slowed and we had thus stretched out the imprinting or sensitive period. This did not occur when we used Nembutal or distilled water. The second point deals with the reduction of emotionality. In test (iv) we had little evidence of emotionality in the meprobamate and the chlorpromazine groups. Emotionality did occur in the control and in the Nembutal group. Thus far, the only way we can interpret this former result is to consider the law of effort. Here we had found that the strength of imprinting was a function of effort or of distance traveled. It may be that, since meprobamate is a muscle relaxant, these effects of meprobamate cut into the muscular tension or other afferent consequences and thus nullify the effectiveness of the imprinting experience. Since, under the same circumstances, we attain perfectly good imprinting in all cases with chlorpromazine, this notion becomes even more tenable (*20a*).

Cerebral Lesions

In addition to drug effects we also studied the results of cerebral lesions on the imprinting behavior of chicks. This was done partly because we had noticed a loss of the fear response in some chicks that had undergone operations—chicks which were old enough to have this response fully developed.

Chicks with a type 1 lesion showed good imprinting at the age of 3 days. This is considerably better than the finding for the control chicks, which only occasionally show this behavior so late in their first few days. Even with this lesion, chicks at 5 and at 7 days showed no imprinting.

Chicks with type 2 lesion showed no imprinting, although some that had been prepared earlier gave no evidence of fear responses to strange objects.

Completely decerebrate animals were run only at 2 days of age, and they followed well, but the tests were inconclusive insofar as imprinting strength was concerned. Diagrams of the various lesions are shown in Fig. 10.

Although the number of animals used in this study is still small, this seems to be a fruitful avenue of approach. Control animals that have had sham operations act essentially like normal chicks. Other experiments involving electrical stimulation are being undertaken, since such stimulation may reinforce imprinting behavior.

Genetic Studies

We have also considered the genetic side of imprinting. We kept ducklings which were highly imprintable and bred them separately from ducklings which showed very little imprinting response. We thus had two groups of offspring,

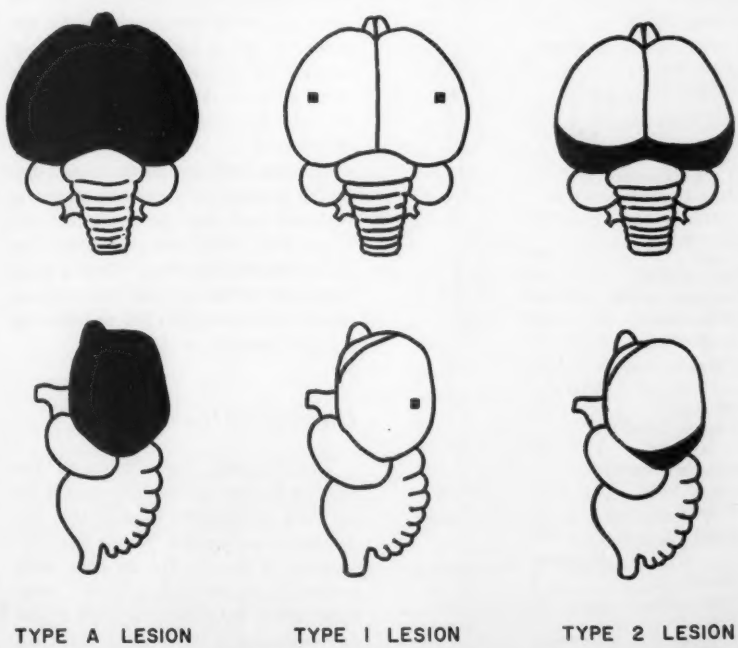


Fig. 10. Three types of lesions in the chick brain, used to study the effect of extirpation on imprintability.

those produced by "imprinters" and those produced by "non-imprinters." There was a clear and significant difference in the imprinting behavior of the two groups, even in the first generation. The offspring of imprintable parents were easily imprinted; those of less imprintable parents were difficult to imprint. The "imprinter" ducklings had imprinting test scores more than three times better than those of the "non-imprinter" ducklings. Similar results were also obtained in a study of bantam chicks. We are also following up those animals which have had experimental imprinting experiences to determine what influence, if any, these experiences have on their behavior as adults. So far the results are inconclusive, but they do suggest that experimental imprinting of mallards affects their behavior as adults, particularly with respect to courtship patterns.

Table 2. Number and imprintability of different experimental animals. Most of the animals were imprinted in runway and mallard decoy situations. Some of the Vantress broilers were imprinted on colored spheres, and the sheep were imprinted on human beings.

Animal	No.*	Imprintability†
Ducks		
Wild mallard	3500	E+
Domesticated mallard	150	E
Peking	200	G
Rouen	100	F
Wood	50	P
Black	50	G
Total	4050	
Geese		
Canada	30	E+
Pilgrim	50	G
Total	80	
Chickens		
Jungle fowl	100	G
Cochin bantam	300	G
New Hampshire Red	100	G
Rhode Island Red	100	G
Barred Rock	200	G
Vantress broiler	500	G+
White Rock	100	F
Leghorn	200	P
Total	1600	
Other Fowl		
Pheasant	100	P
Eastern bobwhite quail	50	G
California valley quail	20	E
Turkey	30	F
Total	200	
Mammals		
Sheep	2	G
Guinea pig	12	G
Total	14	
Total	5944	

* Estimated for fowl, actual for mammals.
† E, excellent; G, good; F, fair; P, poor.

Birds of various species show differing degrees of imprintability. Domestic fowl do show imprinting responses, but the results are not as clear as for wild birds. We have had good success in imprinting some breeds of chicks, and the best imprinters among them are the Vantress broilers. Leghorns, on the other hand, appear to be too highly domesticated to give clear results. Other animals we have used in our experimentation are two kinds of geese, black ducks, wood ducks, turkeys, pheasants, quail, Peking ducks, and Rouens. The various breeds we have so far used in our work and the degree of imprintability found in each are shown in Table 2.

Imprinting in Mammals

The guinea pig is similar to the chick and the duckling in that it is mobile and reasonably self-sufficient soon after birth. For this reason we used it in exploratory work. We first developed a method of obtaining the young from the mother with minimal parental contact. This was done by Caesarean section. However, further work showed that it was sufficient to obtain the young within an hour after they were born, and for the moment we are doing this. Guinea pigs imprint on human beings and follow them about as do the fowl with which we have been working. The maximum effectiveness of the imprinting experience seems to be over by the second day. So far, in using our imprinting apparatus with our usual duck decoy we have obtained best results sometime before the end of the first day of age. Work is being continued so that we can have a more standardized procedure before beginning a major program in this area.

Imprinting and Learning

The supposed irreversibility of imprinting has been particularly singled out by some investigators to show that imprinting is nothing but "simple learning"—whatever that is. We do have some isolated instances which point to a long-range effect, but systematic work is just now beginning in our laboratories. Canada goslings, imprinted on human beings for a period of a week or two, will from that time on respond to their former caretaker with the typical "greeting ceremony," as well as accept food out of his hand. This occurs in spite of the fact that they normally associate entirely with the Canada geese on our duck pond. A more striking case is that of a jungle fowl cock which was imprinted by me and kept away from his own species for the first month. This animal, even after 5 years—much of that time in association with his own species—courts human beings with typical behavior, but not females of his own species. This certainly is a far-reaching effect and is similar to the finding of Räber (*21*), who reported on a male turkey whose behavior toward human beings was similar. An increased amount of homosexual courtship in mallards has been observed with some of our laboratory imprinted animals, which, while not a statistically valuable finding, perhaps points also to long-range, irreversible effects.

Imprinting is currently receiving much attention, and papers on the subject are being published at an impressive rate. Unfortunately, most experimenters appear to be certain that imprinting is identical with simple association learning and design their experiments as studies in association learning. In many instances the animals are too old when used in the experiments to fall within the critical age for imprinting, with the result that only association learning can occur. Papers falling into this category are those of Jaynes (*22*), Moltz (*23*), and James (*24*).

Our own experiments on the relation between association learning with food as a reward and imprinting during the critical period show four distinct differences.

In the first place, learning a visual discrimination problem is quicker and more stable when practice trials are spaced by interspersing time periods between trials than when practice trials are massed by omitting such intervening time periods. With imprinting, however, massed practice is more effective than spaced practice, as shown by our law of effort. Secondly, *recency* in experience is maximally effective in learning a discrimination; in imprinting, *primacy* of experience is the maximally effective factor. The second difference is illustrated by the following experiment. Two groups of 11 ducklings each were imprinted on two different imprinting objects. Group 1 was first imprinted on a male mallard model and then on a female model. Group 2, on the other hand,

was first imprinted on a female model and subsequently on a male model. Fourteen of the 22 ducklings, when tested with both models present, preferred the model to which they first had been imprinted, showing primacy. Only five preferred the model to which they had been imprinted last, showing recency, and three showed no preference at all.

In addition, it has been found that the administration of punishment or painful stimulation increases the effectiveness of the imprinting experience, whereas such aversive stimulation results in avoidance of the associated stimulus in the case of visual discrimination learning.

Finally, chicks and ducklings under the influence of meprobamate are able to learn a color discrimination problem just as well as, or better than, they normally do, whereas the administration of this drug reduces imprintability to almost zero.

Imprinting, then, is an obviously interesting phenomenon, and the proper way to approach it is to make no assumptions. To find out its characteristics, to explore its occurrence in different organisms, and to follow its effects would seem a worth-while program of study.

What can we say in conclusion about the general nature of imprinting? Our best guess to date is that it is a rigid form of learning, differing in several ways from the usual association learning which comes into play immediately after the peak of imprintability. In other words, imprinting in our experiments results in the animal learning the rough, generalized characteristics of the imprinting object. Its detailed appreciation of the *specific* object comes as a result of normal conditioning—a process which in the case of these animals takes a much longer time and is possible days after the critical period for imprinting has passed. It is an exciting new field and is certainly worthy of study.

References and Notes

1. W. Craig, *Am. J. Sociol.* **14**, 86 (1908).
2. O. Heinroth, *Verhandl. 5th Intern. Ornithol. Kong.* (1910), pp. 589–702.
3. ——— and M. Heinroth, *Die Vögel Mitteleuropas* (Lichterfelde, Berlin, 1924–33).
4. K. Lorenz, *J. Ornithol.* **83**, 137, 289 (1935).
5. W. H. Thorpe, *Proc. Linnean Soc. London* **156**, 70 (1944).
6. G. P. Baerends and J. M. Baerends-van Roon, *Behaviour, Suppl.* **1**, 1 (1950).
7. U. Grabowski, *Z. Tierpsychol.* **4**, 326 (1941).
8. F. F. Darling, *Wild Country* (Cambridge Univ. Press, London, 1938).
8a. H. Hediger, *Wild Animals in Captivity* (Butterworths, London, 1938).
9. A. O. Ramsay, *Auk* **68**, 1 (1951).
10. E. Fabricius, *Acta Zool. Fennica* **68**, 1 (1951).
11. A. O. Ramsay and E. H. Hess, *Wilson Bull.* **66**, 196 (1954).
12. M. M. Nice, *Condor* **55**, 33 (1953).
13. R. A. Hinde, W. H. Thorpe, M. A. Vince, *Behaviour* **9**, 214 (1956).
14. The work described in this article was supported in part by grant No. M-776 of the National Institutes of Health, Public Health Service, Department of Health, Education, and Welfare, Bethesda, Md.; by the Wallace C. and Clara A. Abbott Memorial Fund, of the University of Chicago, Chicago, Ill.; and by the Wallace Laboratories, New Brunswick, N.J.
15. H. H. Schaefer and E. H. Hess, *Z. Tierpsychol.* **16**, 161 (1959).
16. E. H. Hess, *Sci. American* **198**, 81 (1958).
17. ———, *J. Comp. and Physiol. Psychol.*, in press.
18. K. M. B. Bridges, *Child Develop.* **3**, 324 (1932); R. A. Spitz and K. M. Wolf, *Genet. Psychol. Monograph No. 34* (1946), pp. 57–125.
19. E. H. Hess and H. H. Schaefer, *Z. Tierpsychol.* **16**, 155 (1959).
20. E. H. Hess, *Ann. N.Y. Acad. Sci.* **67**, 724 (1957).
20a. Further studies are in progress following up this hypothesis.
21. H. Räber, *Behaviour* **1**, 237 (1948).
22. J. Jaynes, *J. Comp. and Physiol. Psychol.* **49**, 201 (1956); *ibid.* **50**, 6 (1957); *ibid.* **51**, 234, 238 (1958).
23. H. Moltz and L. A. Rosenblum, *ibid.* **51**, 580 (1958).
24. H. James, *Can. J. Psychol.*, in press; ———, in preparation.

CURRENT PROBLEMS IN RESEARCH

Marine Sediments

Recent sediments give important clues about conditions under which sedimentary rocks may have been formed.

Francis P. Shepard

Most sedimentary rocks are believed to have been deposited in the seas of the past. One of the primary purposes in geological investigations has been to interpret the conditions under which these ancient sediments were deposited. One of the obvious places to look for guidance in these interpretations is in the deposits of the present. It is, therefore, rather surprising to find how little attention geologists had paid to these recent marine sediments until very recent years. Up until World War II only a few individuals were interested in remedying the situation (*1*). Even the large-scale oceanographic investigations, which were initiated shortly before the war, had helped little in the interpretation of ancient sediments because they had been largely concerned with the deep-ocean floor, and most marine sedimentary rocks now on the continents were probably deposited in relatively shallow seas.

For many years some of the leaders in petroleum geological research had recognized the importance of carrying on investigations of the sediments of today, and finally, in 1950, they developed a project supported by the American Petroleum Institute which had as its aim the study of near-shore marine deposits as an aid in the interpretation of ancient sediments. To date, the field work of this project, which we have administered at the Scripps Institution of Oceanography, has been confined to the northwestern Gulf of Mexico (*2*), although plans are now under way to continue the studies in the Gulf of California. Meantime, a number of other projects, largely supported by petroleum companies, have been carried on elsewhere. Notable among these have been the studies of the Bataafsche Petroleum Maatschappii, of the Hague, around the Orinoco Delta, Trinidad, and the Gulf of Paria (*3*); of the U.S. Geological Survey among the coral reefs of the western Pacific Ocean (*4*); of the Hancock Foundation off the southern California coast (*5*); of the Soviet Union in the various seas that surround the U.S.S.R. (*6*); and of the Germans, especially in the Baltic (*7*).

As a result of these studies of recent sediments it is now easier to interpret

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Fig. 1. A piston corer, modified from the Kullenberg type. A weight attached to the arm extends below the pipe and releases the core barrel and weights when it reaches bottom. The loop of wire allows the core barrel to fall free after release.

the environments in which many sedimentary rocks were deposited. The petroleum companies are making good use of this information in their search for oil.

Instruments

The instruments used in obtaining samples of recent sediments are for the most part quite simple in principle, in contrast to the amazing devices of the nuclear and space age. Cores of the ocean bottom are obtained partly by lowering heavily weighted pipes to the bottom and bringing up the core obtained when the pipe sticks into the soft sediments. A more complicated but much more successful method was devised by Börje Kullenberg (*8*), who placed a piston inside the pipe, which he attached to the winch cable. The heavily weighted pipe is allowed to fall free over the piston after a trigger weight has hit bottom (Fig. 1). The piston greatly reduces the friction of the mud entering the core barrel, so that much longer cores are obtained, and there is much less loss of length than is found in ordinary cores, where the sediment is pushed aside by the coring operation.

Various types of instruments which grab samples from the bottom are used. One of the most successful is the Van Veen grab (*9*), which obtains a sample of about 2 cubic feet. Orange-peel buckets of slightly smaller size are also used, but these are not very successful except in shallow water, whereas the Van Veen has been used at the greatest depths. Other samplers are used in shallow water from a vessel that is under way. These are shaped like a torpedo; they descend nose first, take a bite of the bottom, and return with the nose upward. The sediment is also held in by a lid, which closes after the sampler hits the bottom.

One of the most interesting developments in marine geology has come from the use by geologists of the Aqualung, made famous by its inventor Jacques Cousteau. The scuba (*10*) divers, as they are called, carry with them geological hammers, compasses, inclinometers, and cameras. They work at depths down to about 300 feet, and much exploration of the sea floor has been accomplished in this way. The bathyscaphe, invented by Auguste Piccard, has also been used to obtain data, but from considerably greater depths. Cameras which can take repeated photographs when lowered to the bottom have begun to provide us with much valuable information from great depths (*11*) (Fig. 2).

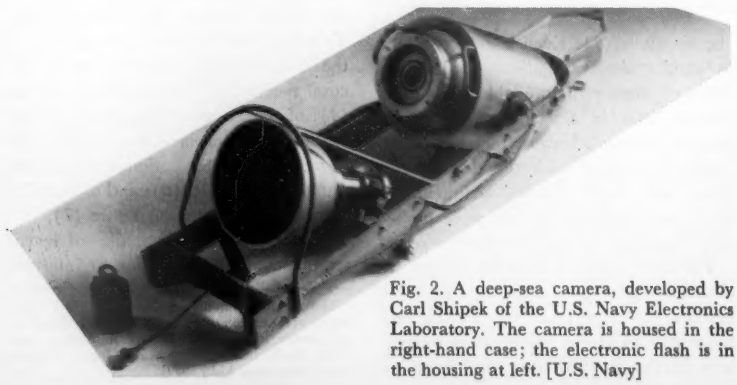


Fig. 2. A deep-sea camera, developed by Carl Shipek of the U.S. Navy Electronics Laboratory. The camera is housed in the right-hand case; the electronic flash is in the housing at left. [U.S. Navy]

Sandstones

In order to see how the characteristics of the recent sediments shed light on the conditions under which the sediments were deposited, let us consider some aspects of the origin of several of the most common types of rock.

Geologists usually define sandstones as rocks consisting of grains of detrital sediments which are predominantly within the size range of 1/16 millimeter to 2 millimeters in diameter. These rocks have been deposited either in the ocean or on the land, and many of them have been deposited along the border between the two, so they belong to some extent in each category. In general, sandstones are rather poor in fossils, and therefore the geologists need other criteria to interpret their origin.

Sheet sands. One common type of sandstone is characterized by its widespread continuity and is called a sheet sand. Some of these are formed by braided streams on a broad plain at the base of a mountain range. Although these fanlike deposits are well known to geolo-

gists, they are not easy to recognize in ancient rocks. Sheet sands containing marine fossils, and particularly those including forms of life characteristic of the open sea, have been even more difficult to interpret than the fans. Studies of the sea floor have shown that the continental shelves have many extensive areas of sand. The most puzzling thing about such sand areas is that the majority of them lie outside zones where the sediments are muddy—such as, for example, the broad sand belts along the outer continental shelf off the coasts of China. A similar outer-shelf sand has been studied off the Texas coast. The finding of shells that have been dated, by the carbon-14 method, as thousands of years old shows that, at least here, the sands may not have been deposited under present-day conditions. We know that the sea stood considerably lower during the ice ages, (because the water was locked up in glaciers), and it is believed that the rivers coming out onto this shelf carried more sand during glacial times than at present. As the sea rose, the rivers occupied estuaries and began depositing their sediments in these embayments, leaving many of the shelf sands uncovered. Furthermore, with the change in climate many rivers ceased transporting much sand to the sea and began introducing mud. This fine sediment could be deposited only where the currents of the sea floor were weak. Along many portions of the continental shelves the currents are strong enough to prevent mud deposition. These same currents move the sand back and forth on the outer shelf and may introduce the outer-shelf faunas into these former terrestrial or coastal sands.

Another type of marine sheet sand is found in shoal water where tides are very pronounced. Vast areas in the southern part of the North Sea are covered with sand which has been introduced in part from the English Channel by tides which run powerfully through the Straits of Dover. Another large area covered with sand occurs southeast of Cape Cod, in Nantucket Shoals, where the tides are constantly shifting the sand derived from the erosion of the cape. Farther to the east, on Georges Bank, there are equally extensive shoals. Here, much of the sand is remarkably pure quartz and well rounded, resembling the great glass-making sandstones of the Middle West, known as the St. Peter sandstone. Few fossils are found in the St. Peter sandstone, and a striking scarcity of shells characterizes the sands of Georges shoals. These, however, are only clues, and the two sands doubtless have quite different origins.

Shoestring sands. Other sandstones are characterized by their elongation and their lens shape in cross section. These sometimes form a reservoir in which oil accumulates, so their origin is a problem of much interest. Some of them show the characteristics of river sands, but others appear to be comparable to the great sand islands (Fig. 3) which form barriers along many of the lowland coasts of the world (*12*). By studying the characteristics of the recent sands in each of these environments, it is possible to identify the origin of many of the shoestring sandstones. Most of the sandy barrier islands have a straight or gently curving margin seaward and a scalloped margin facing the lagoon, whereas the river-channel sands have a slightly winding shape, with the two sides roughly parallel. In cross section the barrier islands are usually broader at the base than above but show asymmetry, whereas the river channel sands have a narrow concave base, are wider above, and have a rough bilateral symmetry.

The sediments are also quite different. The barrier sands are much better sorted, especially on the outside, where there are beaches and dunes. Some of the inner marshy flats developed by washovers from the ocean are somewhat muddy, especially where there are extensive ponds. The river sands are, in general, poorly sorted and have more lenses of gravel and of muddy sediments than the barriers. Unlike the sediment of the barriers, that in the river channels shows no contrast on the two sides. Studies of grain orientation show that in both cases the grains are elongated in the direction of flow (*13*). Therefore in the river channels the grains trend along the length of the channel whereas in the barrier islands, which receive their sediment from the outside, the grains are largely oriented across the sand body.

The faunas and floras are quite different. The river deposits contain an abundance of wood, which is rather scarce in the barriers. The ocean side of the barrier contains ocean shells, whereas the lagoon side has estuarine types. Shells are much scarcer in the river channels and consist largely of freshwater types.

Distinguishing between the beach and dune sands of ancient barrier-island deposits or of any coastal deposits has been somewhat difficult. Considerable study of the recent sands has provided some useful clues. Study of the type of bedding is often helpful, because the wind makes a special type of cross-bedding which is distinctive (*14*). When this cannot be found, other criteria are helpful. If the outcrops contain both dune and beach deposits side by side, the grains of the dune sands will almost always be more rounded (*15*) and the contrast will develop at the immediate point of contact, indicating that the wind has selected rounder grains, since there has not been enough transportation to produce rounding. The dunes almost always have more silt than the beach sands.

The idea long held by geologists that barrier islands are formed on coasts of emergence led to the thought that they were ephemeral features and, therefore, not likely to be preserved and to become reservoirs of oil. The work along the coast of the Gulf of Mexico, however, has shown that many or perhaps most of the barrier islands were built up by the waves as the sea level rose at the end of the glacial period, or after abandoned deltas sank beneath the sea. It seems likely that reexamination of shoestring sands will show that many of them are old barriers, as claimed many years ago by N. W. Bass (*12*).

Deep-sea sands. Geologists have long been puzzled by layers of coarse-grained sandstone interbedded with thick masses of shale, the former suggesting shallow-water conditions and the latter appearing to have been deposited in quiet deep water. They were at a loss to explain the sudden change of depositional conditions that was implied, particularly when it was found that the faunas of some of the shales were those representing deepwater conditions. These sandstones contain ripple marks and cross-bedding, both generally believed, in the past, to be a sure sign of shallow-water deposition. They even contain fragments of wood and shallow-water organisms. It was thought by some geologists that these sand and shale sequences indicated rapid, large-scale crustal movements so that deep-sea conditions alternate with those of shallow water or even of land.

The explanation of the phenomenon came when the Dutch geologist Kuenen (*16*) demonstrated with tank experiments that sand could be transported by currents resulting from a relatively heavy suspension of sediment and water. These currents can in turn be induced by

slumping of the water-saturated sediments on a submarine slope, probably as the result of the development of spontaneous liquefaction (*17*). The extensive coring operations conducted by the Lamont Geological Observatory (*18*) did much to establish the great depth to which sand could be carried by this means. It can even be transported along a deep-ocean floor with little or no gradient. Almost all recent oceanographic cruises in various parts of the world have added to the record of these amazing currents. Many of them travel down submarine canyons, carrying the sands of the canyon head and the canyon walls out onto the deep fans which are found at the lower end.

The turbidity-current explanation for such sandstone layers has now been used widely, probably without enough caution in many cases. Actually there has been little study of the characteristics of deep-sea sands. Oceanographic institutions appear to have put too many of their resources into obtaining deep-sea cores and too little into studying the results. From preliminary investigations it has appeared that may of the deep-sea sands are graded—that is, the grains are coarse at the bottom and progressively finer above. This characteristic was also found in the experiments by Kuenen. Analyses of many of the deep-sea sands at Lamont and at Scripps, however, have shown that many of them are not perceptibly graded; others have alternating coarse and fine sediments in the same sand zone. Furthermore, graded bedding can be produced in several other ways, including the stirring up of sediment on the sea floor by great storm waves, so graded bedding by itself is not a safe criterion for assigning a turbidity-current origin to these sands (*19*).

Some study of the constituents of deep-sea sands indicates that there may be fewer organic constituents in them than in the sands of the slope from which they were derived. Admixture of deep- and shallow-water Foraminifera suggests that material has been picked up during the passage of the currents down the oceanic slopes. Much remains to be learned, however, before reliable interpretation of deepwater sand layers can be made.

Shales (Mudstones)

Various names have been applied to the sedimentary rocks which consist of grains of silt and clay (*20*), but the most common names are shale and mudstone or mud rock. Among the sedimentary rocks found on the continents, shale is generally considered to constitute more than 50 percent, whereas sandstone accounts for only about 20 percent. Just the opposite is found on the continental shelves, where sand covers more than half of the surface area and about 30 percent could be classified as mud—that is, silts and clays. This contrast constitutes something of an enigma, since so far as we know most sedimentary rocks were formed in shallow marine waters. The enigma is explained by the somewhat atypical nature of present-day shallow marine sediments. This, in turn, is due to the recent rise in sea level; many of the sands of the continental shelves are not yet covered by the muds derived from the continents. Furthermore, there were extensive shallow bays or epeiric seas in the past, and these are not well represented at present. If the continental glaciers of Antarctica and Greenland should melt, the rise in sea level would produce much larger embayments in which the protecting headlands would favor the deposition of fine-grained material to a greater degree than on the exposed continental shelves, where both waves and ocean currents interfere.

Continental shelf shales. To judge from available information, the chief areas of active deposition on the continental shelf have muddy sediments. Large areas on the continental shelf of the northwest Gulf Coast are mud-covered, and cores show that the muds are at least as thick as the length of penetration of the coring devices (10 or 20 feet). These deposits have little stratification, although they may develop fissility upon compaction. The chief fossils found in these shelf muds are Foraminifera. On the outer shelf, except near a delta, the Foraminifera are largely planktonic (the free-floating type of plankton). Nearer shore, on the other hand, the Foraminifera are largely benthonic—that is, bottom dwellers. Thus, these unicellular organisms often give a clue as to the part of the shelf on which they were deposited. Many of the benthonic Foraminifera dwell only at certain depths, and the range is limited. The sediments on the shelves off most of the large rivers are muddy, although the outer shelf, as explained previously, is usually covered with sand.

The coarse fraction of the shelf muds varies in composition from place to place, but it usually contains echinoid spines along with Foraminifera and small amounts of glauconite. Shell fragments are more common than in most other environments.

Muds of lagoons and estuaries. Most bays protected by sand islands receive mud deposits which are usually quite distinct from those of the open continental shelf. The echinoids and glauconite of the shelf muds are rare in the protected bays. Shells and Foraminifera are both found in typical bay deposits, but they differ considerably from those of the shelf. Among the shells, oyster shells are particularly common and often form reefs. In old bay deposits these reefs are frequently found cutting across the shales and mudstones. As for other shells, the bay deposits contain only a few species, in contrast to the diverse shell faunas of the shelf. In the Foraminifera found in bay deposits there are virtually no planktonic forms; as in the case of shells, the deposits usually contain only a few species.

The stratification is found to be poor wherever the bays support abundant burrowing organisms. The chief exceptions are bays where there are stagnant areas in the water mass, as in some bays with deep holes or in arid areas where there is little entering drainage. Stratification may also be preserved if the deposition is rapid. In arid bays the sand grains mixed with the mud are apt to have coatings of calcium carbonate, deposited as the result of evaporation.

Delta margin shales. The areas where mud deposition is going on most rapidly are at the margins of the large deltas (Fig. 4). At the mouths of the Mississippi, for example, mud is building up the slopes at rates of a foot or more per year (*21*) in contrast to typical shelf muds which have only accumulated a score of feet in the past 10,000 years or more since the sea came in over the outer shelf. This great contrast must have held also in the past. It is, therefore, somewhat puzzling that geologists have found so few shales to which they attribute a deltaic origin. Most of the old formations which are considered deltaic consist of sandstones, such as the Devonian Catskill sandstones of New York state that represent a great delta built into the sea from the old land of Appalachia.

Perhaps the scarcity of ancient mud deltas is explained by failure to recognize these deposits. Too much attention has been paid to the deltaic structure (Fig. 5), which geology textbooks show as a series of highly in-

clined foreset beds built over the horizontal bottomset beds and in turn covered by horizontal topset beds. The foreset beds represent a deposit formed on and conforming to an already existing slope, whereas the bottomset beds develop on the flat bottom of the body of water and the topset beds are deposited above the forward-building inclined series. This diagram applies to many small lake deltas built largely of sand, but it does not apply to the large muddy deltas built into the ocean. These latter have foreset beds with very gentle inclinations, rarely over one-half degree; hence, the discordance between the bottomset, foreset, and topset beds is very slight and could easily be overlooked in rock formations.

Studies of modern deltas have shown other characteristics which would be of more use than deltaic structure in identification of the old deltas. Among these is the good development of lamination in the topset beds. In most cases the laminae represent alternation between clayey and sandy or coarse silt layers. Such lamination is common among ancient shales, and it may be that much of it is deltaic but has not been so recognized. The deltaic deposits have an abundance of wood fibers, since most rivers transport great quantities of wood to the sea. In the swamps bordering some river channels future thin coal beds may be forming. Fossils other than wood are scarce in deltaic deposits. The rivers in general transport a great deal of mica; much of this is deposited at or near the river mouths, although it is also abundant in other environments. Small aggregated grains of orange or brown color are common in recent deltaic deposits and may be found as well in ancient ones.

Black shales. Geologists have been debating the origin of black shales for generations. The Chattanooga shale of the southern and midwestern states has been intensively investigated. In addition to being black, it is well laminated, although the laminae do not show the frequent alternation of fine and coarse sediment that is found in deltaic deposits. Presumably, few burrowing animals were present to disturb the layering. It is generally agreed that deposition conditions were those of stagnation. One group of geologists believes that the shale had a shallow-water origin and another group considers it a deepwater deposit. Among the findings which suggest that the water was shallow are the presence of ripple marks, the presence of occasional layers with cross-bedded sands, and the high degree of sorting. This, however, is not entirely convincing to marine geologists, since we have many photographs of ripples now forming in deep water and the

Fig. 3. A sandy barrier island along the coast of Alabama. Indications of overwashes into the lagoon are shown at several places, notably in the center. Underwater sand bars are indicated near the shore in clear water. [U.S. Coast and Geodetic Survey]

deepwater sediments include well-sorted and cross-bedded sands. A comparison with the deep floor of the Black Sea, where stagnant conditions exist at the bottom, is of interest, since the sediments include laminated black mud along with gray mud and calcareous deposits (*22*). On the other hand, the underlying unconformity and overlying shallow-water beds of the Chattanooga shale argue against deposition in such a deep basin. Black muds are also found in some of the fiord basins of Norway (*23*), where there is considerable depth of water. Here, however, we have a situ-

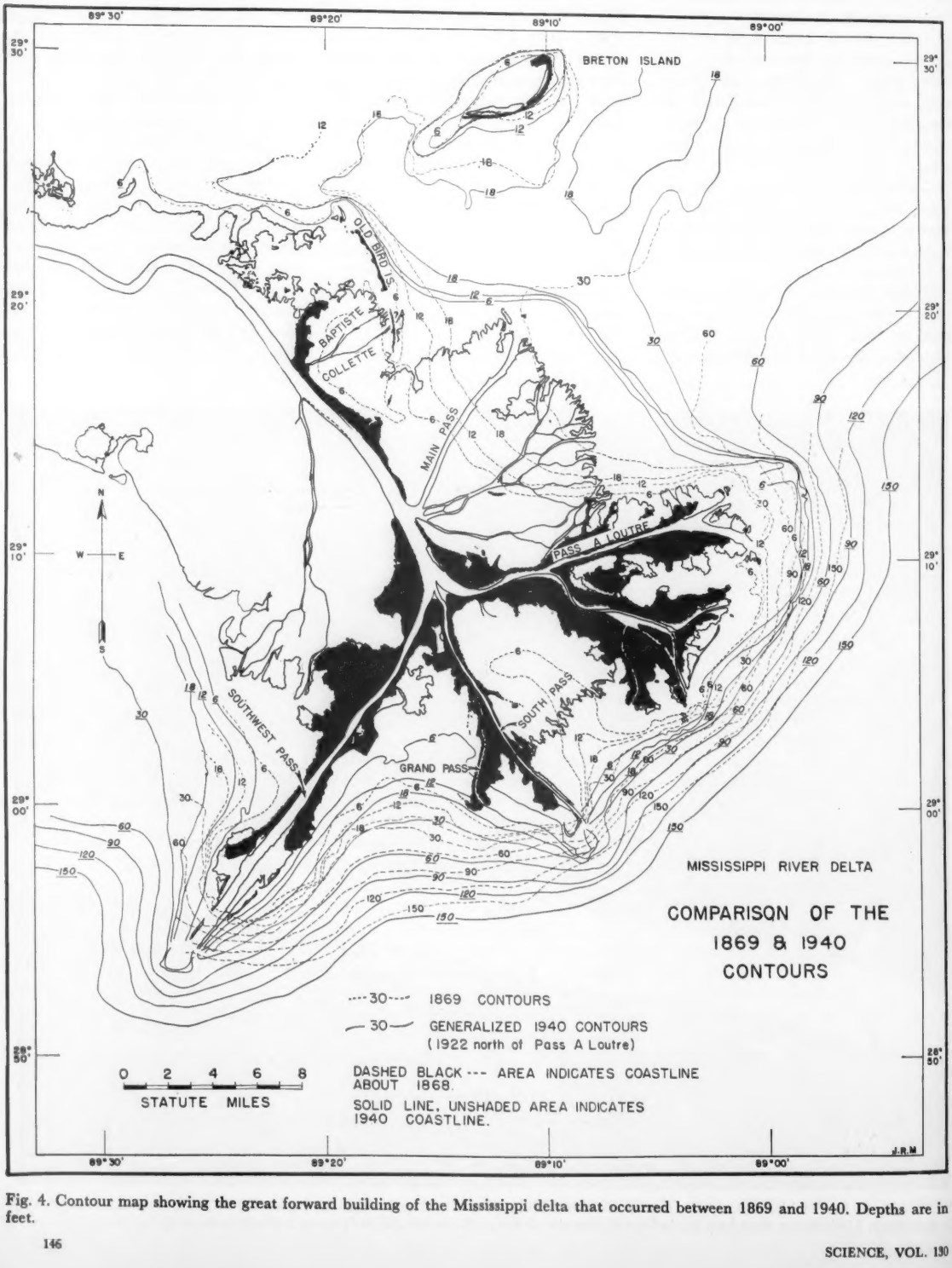


Fig. 4. Contour map showing the great forward building of the Mississippi delta that occurred between 1869 and 1940. Depths are in feet.

ation resulting from overdeepening of valleys by glaciation, and there is no sign of glaciation in the Devonian, when the Chattanooga shale was deposited. Furthermore, the Chattanooga shale forms a widespread blanket rather than a deposit formed in a narrow trough. The same objection applies to comparison with the laminated black muds of Kaoe Bay in Indonesia (*24*). Black color in sediments has been found in such bays as the Bay of Danzig and elsewhere in the Baltic Sea (*25*), but here the black color is due to excess of organic matter rather than to stagnation, and burrowing animals exist which churn up the bottom. In fact, it seems likely that we have not yet discovered a modern environment which contains all of the characteristics of that which produced the laminated black shales.

Deep basin shales. The deep basins and troughs bordering the southern California coast represent another environment in which mud is accumulating although it is interlayered with turbidity-current sands. The muds are dark green in color. Except for the sand layers, stratification is poor, and there is virtually no lamination except in the relatively stagnant Santa Barbara basin. In the Gulf of California, on the other hand, some of the basin muds are well laminated, having alternate layers rich in diatoms. Here, although there is some circulation, burrowing organisms have not destroyed the stratification; this is probably due to the annual overturn in the gulf in winter, which brings an abundance of nutrients into the surface waters and results in great blooms of plankton. The diatoms are the chief planktonic contributor to the sediments. Comparison with the diatomite shales of Miocene age in California seems justified. These were probably also of deepwater origin, to judge from fossil fish fauna (*26*).

Limestones and dolomites. The chief carbonate rocks are called limestone when calcite ($CaCO_3$) is the dominant mineral and dolomite or dolostone when the mineral dolomite ($CaMgCO_3$) is most common. Among recent calcareous sediments, only calcium carbonate is found; this suggests that dolomite is formed later. If the carbonate sediments are fine-grained and poorly consolidated, the limestone is referred to as a chalk. These carbonate rocks are comparable to sandstones in their abundance among marine sedimentary rock formations. The study of recent sediments has shown that almost all of the present-day carbonate deposits are developing in the tropics or subtropics. Ancient limestones and dolomites are found at all latitudes, and this has been considered (no doubt with good reason) an indication either that the climates of the past were warmer than those of the present or that the pole or the earth's crust has been migrating so that localities now at high latitudes were formerly near the equator.

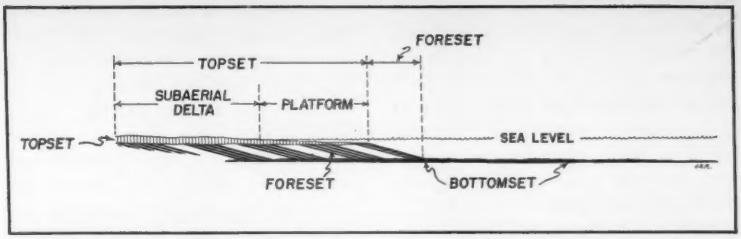


Fig. 5. Conventional diagram of a growing delta. Large marine deltas differ from this in having much lower foreset slopes.

The calcareous rocks include a variety of types. These can be conveniently subdivided into fragmental limestones, reef limestones (commonly called bioherms), chalk and other fine-grained calcareous rocks, and oölites. Each of these has its counterpart in the present seas. Much information concerning these environments has come from studies sponsored by the American Museum of Natural History (*27*) and by the U.S. Geological Survey (*28*).

Fragmental limestones. Probably there are more limestones consisting of fragments of shells, corals, and other calcareous organisms than any other type. Similarly, on the sea floor there appear to be more fragmental calcareous deposits than any other kind (*29*). For example, most of the wide shelf off the west coast of Florida has a cover of shell sands and fragments of calcareous algae. It is thought that the shelf off Yucatan has a similar cover. Most of the tropical islands of the Pacific are bordered by shelves with calcareous detritus. This material is transported by the waves and currents very much as the quartz sands and other land-derived minerals are transported across the shelves in cooler climates. Bars like those of Nantucket Shoals are developed out of the fragmental lime debris; hence, limestones often have the cross-bedding characteristic of sand bars.

Reef limestones. Geologists have long recognized that many limestones had their origin as ancient coral reefs. Much of the early exploration of the oceans, including that of Darwin, was concerned with the coral islands. Although the present-day corals are quite different from those of the Paleozoic, some of the reef characteristics are found in the ancient reefs. The steep reef margins are clearly recognized in many Paleozoic reefs with highly inclined flanking layers made up of coral talus broken from the reefs by the waves. Many of the ancient reefs consist dominantly of calcareous algae, and this is also true of many reefs of today. Another characteristic of the ancient reefs is the general absence of stratification. This is due to the upward growth of the reef which accompanied the subsidence of the bank on which it was growing. The interlacing of the corals allows little stratification. The dolomites in the eastern Alps, with their structureless appearance, are said to represent an example of these ancient reefs, although most of the coral structure has disappeared because of the ease with which carbonate minerals recrystallize.

Chalk and fine-grained limestones. Chalk, which used to be used universally for writing on blackboards, is found to consist of an abundance of planktonic organisms, of which Foraminifera are an important constituent. For a long time it was thought that chalk was a deepsea deposit comparable to the *Globigerina* oozes. More careful study, however, showed that its benthic organisms are primarily shallow-water types. The plankton can accumulate in shallow water as well as in deep, provided they are not masked by other material. Some of the chalks of the southeast United States have been shown to consist of coccoliths (*30*), parts of a small planktonic lime-secreting plant. These plant remains are easily altered under pressure, and therefore old formations are not likely to preserve them. Other fine-grained lime deposits appear to have been deposited as the result of chemical precipitation from supersaturated waters. This was probably the origin of the lime muds of the Bahamas (*31*). Still other fine-grained limestone may

have been formed in the deep waters at some distance from reefs, where only the finest reef debris has been transported to the site of deposition. Such fine-grained calcareous muds are found at depth around some oceanic reefs, but elsewhere the Foraminifera are so common that the sediments are relatively coarse, even at depth.

Oölitic limestone. Many limestones consist of small rounded grains looking like fish roe; hence the name, derived from *oö,* a shortening of the Greek *oion,* meaning egg. In section the oölites show concentric layers and, in some cases, a nucleus. These oölitic limestones are particularly common in the Jurassic of Europe, and it was the English who first called the rocks of this period the oölite series. Modern oölites are particularly well represented in the extensive Bahama banks (*32*). The spectacular underwater dunes, which can be seen so well through the clear water when one is flying over these banks, consist largely of oölites. These will undoubtedly produce limestones with much cross-bedding. The Bahama oölites are generally attributed to chemical precipitation which occurs when cool waters rise from the depths onto the warm banks, and the warming causes supersaturation. Deposition is especially active at the edges of the shallow platforms or along the edges of the tidal channels. The roundness is due in part to concentric deposition and partly to the rolling of the grains by the waves and currents. The unstable dune area is not favorable for the growth of bottom-dwelling organisms, and fossils in such deposits are relatively rare. This is apparent in the elevated oölites found on various islands in the Bahamas. In some areas oölites occur on the continental shelves as relics of former shallow-water conditions. This is particularly well illustrated by the outer shelf off western Florida (*33*). Oölites are not all marine formations. In fact, they develop very commonly in dry basins around lakes, such as Great Salt Lake.

Marine Conglomerates and Breccias

The sedimentary rocks containing an abundance of pebbles, cobbles, or boulders in a matrix of finer material are called conglomerates if the fragments are somewhat rounded and breccias if they are largely angular. Most conglomerates are land deposits, developing especially in the fans at the base of mountain slopes. Rivers carry pebbles into the sea, and various types of rock fragments are broken from cliffs, landing in the shallow adjoining seas, but in neither case are extensive marine conglomerates likely to develop. This is partly because the waves in shallow water grind up the large fragments into sand or finer material and because the waves are not capable of carrying the pebbles out far from the shore. In fact, waves tend to work the coarser material in towards shore, building it up as rampart beaches.

There are, however, many conglomerates and breccias which lie interbedded between formations that have marine shells and, in some cases, deepwater assemblages. The Flysch formation in the Alps is notable for such an alternation between conglomerates or breccias and deepwater mudstones. Their origin is not quite certain. Some of the conglomerates grade upward into fine material and hence their presence has been attributed to turbidity currents (*34*). Others include boulders, some of them as big as a house, and do not appear to be due to turbidity currents, since they lack all signs of graded bedding. These Alpine breccias, and probably also many of the ungraded conglomerates, can be explained by a type of submarine slope failure which has allowed the rocks from the upper slope or even from the adjacent mountain walls to catapult down the sides of a deep basin and come to rest on top of the fine-grained basin sediments. The fine sediment in the interstices between the large fragments may consist of deep-sea deposits introduced after the slides occurred. Such conglomerates have been found at the base of the cliffs outside the Yucatan shelf (*35*). They are also well illustrated in the Pliocene formations of Ventura County, California (*36*), and in western Venezuela (*37*).

The study of submarine slopes has shown that many of them are very unstable (*38*). They are particularly likely to slide at the time of an earthquake. Many cable breaks have resulted either from these slides or from turbidity currents (*39*).

Other kinds of marine conglomerates and breccias may be formed through the rafting of rock fragments, although the "plums" in this type of "pudding-stone" are apt to be few and far apart. The most important means of floating rocks out into the sea is by icebergs or drift ice. In the areas where there are many icebergs, as around Antarctica, the sea floor is littered with pebbles. This produces what is called a glacial marine sediment. Such sediments are found beneath the most recent sediments in the cores of the North Atlantic (*40*), representing the glacial stages of the Pleistocene, when icebergs were more common. On a smaller scale pebbles are rafted out by vegetation, especially beyond the mouths of tropical rivers. Also kelp, when broken off by the waves, often carries rock fragments in its rootlike holdfasts, and enough may be accumulated this way to make a local conglomerate.

Concluding Remarks

The foregoing suggestions regarding the origin of marine sedimentary rocks must be considered as partly speculative because they are based largely on investigations that are far from complete, and vast areas of the sea floor have not been explored at all by marine geologists. The introductory studies, however, seem to have shown that many of the old ideas about marine sedimentation are outmoded. Thus, sandstones and even conglomerates are not confined to shallow water, as was formerly supposed, but can form in deep water provided there are relatively steep slopes down which slides and turbidity currents may transport the material to the deeps. Similarly, the ripple marks and cross-bedding, formerly supposed to indicate shallow-water origin, have now been found also in deepwater sediments. We are still looking for the most reliable criteria for distinguishing between the deepwater and shallow-water sands, although graded bedding has already proved somewhat helpful when related to the occurrence of deepwater organisms in the underlying and overlying beds.

On the continental shelf so many exceptions have been found to the old concept that fine sediments are deposited outside of, and in deeper water than, coarse sediments that determination of grain size as a means of "finding the shoreline"—a method used so much by geologists—seems open to reexamination. On the continental shelves many of the sand zones outside deposits of mud appear to be relics of a period of lower sea level, but currents of sufficient strength to transport sand are found on the outer shelves in many places. Therefore, sand formations may be deposited on the continental shelf contemporaneously with, and yet farther from shore than, mud formations, and the two may have different geographical sources.

The frequent occurrence of mud deposits around the advancing margins of modern deltas and the very infrequent occurrence of ancient shales considered to be deltaic suggests that some or many ancient deltas may not have been recognized. The characteristics found in the sediments around the margin of the Mississippi and other great deltas should prove helpful in recognizing such deposits among rock formations. Similarly, the various types of calcareous deposits found on the shelves and banks of the world are providing means for determining the conditions under which the limestones now on the continents were deposited.

In concluding, it should be emphasized that the study of recent sediments can at best provide some useful clues which help us to interpret the past. The thoroughgoing field examination of stratigraphic relationships will still be the most important method available to the geologist.

References and Notes

1. Among the books published as a result of these studies are P. D. Trask, *The Origin and Environment of Source Sediments of Petroleum* (Gulf, Houston, Texas, 1932); ———, Ed., *Recent Marine Sediments, a Symposium* (Am. Assoc. Petrol. Geologists, Tulsa, Okla., 1939).
2. Among the results published to date are F. P. Shepard and D. G. Moore, *Soc. Econ. Paleontol. and Mineral. Spec. Publ. No. 3* (1955), pp. 78–96; P. C. Scruton, *Bull. Am. Assoc. Petrol. Geologists* 40, 2864 (1956); R. H. Parker, *ibid.* 40, 295 (1956); F. B. Phleger, *Cushman Foundation for Foraminiferal Research* (1956), vol. 7, part 4, pp. 106–151; F. P. Shepard, *Bull. Am. Assoc. Petrol. Geologists* 40, 2537 (1956).
3. Tj. H. van Andel and H. Postma, *Reports of the Orinoco Shelf Expedition* (1954), vol. 1; D. J. G. Nota, *Reports of the Orinoco Shelf Expedition* (1958), vol. 2; G. W. Koldewijn, *Reports of the Orinoco Shelf Expedition* (1958), vol. 3.
4. K. O. Emery, J. I. Tracey, Jr., H. S. Ladd, *U.S. Geol. Survey Profess. Paper No. 260-A* (1954).
5. K. O. Emery and S. C. Rittenberg, *Bull. Am. Assoc. Petrol. Geologists* 36, 735 (1952); W. L. Orr, K. O. Emery, J. R. Grady, *ibid.* 42, 925 (1958).
6. N. M. Strakhov *et al.*, *The Formation of Sediments in Recent Basins* (Academy of Sciences of the U.S.S.R., Moscow, 1954).
7. *Geol. Rundschau* 47, 24 (1958).
8. B. Kullenberg, *Svenska Hydrograf.-Biol. Komm. Skrifter, Ny Ser. Biol.* 1, 1 (1947).
9. Illustrated in H. S. Ladd, *Science* 129, 69 (1959), Fig. 4.
10. The term *scuba* is coined from the words "self-contained underwater breathing apparatus."
11. J. Y. Cousteau, *National Geographic* 113, 373 (1958).
12. N. W. Bass, *Bull. Am. Assoc. Petrol. Geologists* 18, 1313 (1934).
13. R. H. Nanz, Jr., *ibid.* 38, 96 (1954); J. R. Curray, *J. Geol.* 64, 117 (1956).
14. E. D. McKee, *J. Geol.* 47, 64 (1939).
15. M. A. Beal and F. P. Shepard, *J. Sediment. Petrol.* 26, 49 (1956).
16. P. H. Kuenen and C. I. Migliorini, *J. Geol.* 58, 91 (1950).
17. K. Terzaghi, *Proc. Texas Conf. on Soil Mechanics and Foundation Engineering, 8th Conf.* (1956).
18. D. B. Ericson, M. Ewing, B. C. Heezen, G. Wollin, *Geol. Soc. Am. Spec. Paper No. 62* (1955).
19. Other features such as "fluting" and "involute structures," found in ancient sandstones, which are supposed to be of turbidity-current origin, have not yet been recognized in the sea-floor sediments.
20. Silt is usually defined by geologists as sedimentary rock in which the grains range from 1/16 to 1/256 millimeter in diameter; clay, as that composed of finer particles, including colloidal material.
21. F. P. Shepard, *Bull. Geol. Soc. Am.* 66, 1489 (1955).
22. L. P. Smirnow, in *Habitat of Oil, a Symposium* (Am. Assoc. Petrol. Geologists, Tulsa, Okla., 1958), p. 982; a compilation from many sources.
23. K. M. Strom, in *Recent Marine Sediments* (Am. Assoc. Petrol. Geologists, Tulsa, Okla., 1939), p. 356.
24. P. H. Kuenen, *The Snellius Expedition* (1942), vol. 5, part 3, p. 28.
25. C. O. Dunbar and J. Rodgers, *Principles of Stratigraphy* (Wiley, New York, 1957), p. 205.
26. L. R. David, *Geol. Soc. Am. Spec. Paper No. 43* (1943).
27. N. D. Newell, *Bull. Am. Museum Natl. Hist.* 109 (1956).
28. K. O. Emery, J. I. Tracey, Jr., H. S. Ladd, *U.S. Geol. Survey Profess. Paper No. 260-A* (1954)
29. C. O. Dunbar and J. Rodgers, *Principles of Stratigraphy* (Wiley, New York, 1957), p. 274.
30. M. N. Bramlette, *Bull. Geol. Soc. Am.* 69, 121 (1958).
31. L. V. Illing, *Bull. Am. Assoc. Petrol. Geologists* 38, 1 (1954).
32. ———, *ibid.* 38, 35 (1954).
33. H. R. Gould and R. H. Stewart, *Soc. Econ. Paleontol. and Mineral. Spec. Publ. No. 3* (1956), p. 2.
34. P. H. Kuenen, *J. Geol.* 61, 363 (1953).
35. M. Ewing, D. B. Ericson, B. C. Heezen, in *Habitat of Oil, a Symposium* (Am. Assoc. Petrol. Geologists, Tulsa, Okla., 1958), Fig. 27.
36. M. L. Natland and P. H. Kuenen, *Soc. Econ. Paleontol. and Mineral. Spec. Publ. No. 2* (1951), p. 76.
37. O. Renz, R. Lakeman, E. Van der Meulen, *Bull. Am. Assoc. Petrol. Geologists* 39, 2053 (1955).
38. K. Terzaghi, *Proc. Texas Conf. on Soil Mechanics and Foundation Engineering, 8th Conf.* (1956).
39. B. C. Heezen and M. Ewing, *Am. J. Sci.* 250, 849 (1952).
40. M. N Bramlette and W. H. Bradley, *U.S. Geol. Survey Profess. Paper No. 196* (1942), part 1.

News of Science

Commission To Study Proposed Department of Science Asked

Disregarding the recommendations of administration spokesmen, a Senate committee has called for a Hoover-type commission to study the problems connected with the establishment of a Department of Science and Technology. In its report, the Committee on Government Operations, chaired by Hubert Humphrey (D-Minn.), also pointed out that such a commission is an "essential first step" if the Congress is eventually to gain access to the information it needs to legislate on scientific matters. The committee report, which is unusually pointed in its criticism of administration practices, represents a new move in a growing conflict between Congress and the Executive over access to scientific information.

Behind the Senate move is the fact that the Congress has no legal access to information and individuals in such executive agencies as the Science Advisory Committee and the Federal Council for Science and Technology. These agencies, which are staffed by many of the leading scientists and engineers of the country, enjoy "executive privilege" and do not have to respond to congressional calls for testimony. On a number of occasions, officials of these executive agencies—for example, James Killian, former presidential science adviser—have refused to testify. This practice has so angered many members of Congress that they have seized on the Department of Science bill as a means of solving their problem. If a Department of Science is created, its officials, like those of the other federal departments, will have ample reason, because of the legal and fiscal set-up, to be responsive to Congress, which controls the purse strings.

The idea of establishing a commission to study proposals for a Department of Science came up early in congressional hearings on a bill (S. 676) to create such a department. The suggestion was first advanced by spokesmen for the Engineers Joint Council and was later summed up by Wallace Brode, Science Advisor to the Secretary of State and retiring president of the AAAS Brode said, "Two major decisions are required, one as to whether a Department of Science should be formed, and,

second, as to the composition of such a Department. A Commission of governmental and nongovernmental experts in science and nonscience areas, similar to a Hoover Commission . . . , might consider these problems, and especially the second phase."

This proposal, which had the support of almost all of the witnesses at the hearings (even that of some who were opposed to establishment of a Department of Science) was taken up by the Senate committee and drafted into a bill. Those who did not support the proposal were the witnesses for the administration who had been opposed to the Department of Science bill. The principal administration spokesmen were Alan T. Waterman, director of the National Science Foundation, and William F. Finan, assistant director for management and organization at the Bureau of the Budget. Waterman suggested that such a commission would be premature in view of the fact that insufficient time has passed to allow full evaluation of new government agencies such as the Federal Council for Science and Technology. He said that there should be a trial period of 1 or 2 years for assessment of the work of such agencies before any study preliminary to setting up a new department is made. The Budget Bureau's spokesman offered two main points in support of his opposition. First, he stated that any new department should be established around an appropriate "major purpose." "Science and technology," he said, "cannot be said to constitute a major purpose of Government." The second objection was based on the Bureau's belief that setting up a commission would be a waste of time and money because the case for a new department would prove to be untenable.

These views did not sit well with the committee. "The inevitable conclusion," the committee report states, "was reached that it is the desire of the present administration to continue to center within the Executive Office of the President all control over civilian science operations." The report ended with a recommendation that a Department of Science Commission, as called for in the committee bill, be established.

The chances that such a commission will be established are much better than they normally would be, according to observers, because of the supplemental issue of congressional access to Executive information and personnel. If Senator Humphrey, who is known for his zeal, succeeds in alerting his fellow members to the issue, the bill calling for a Department of Science Commission may be approved by both House and Senate before the 86th Congress adjourns next year.

Radiation Study Delayed

A government study on radiation protection, described as "well under way" on 3 April, has yet to be completed. Authorities working on the study, which is designed to determine how the government can best be organized to monitor fallout, have set no date for its completion. Participating in the study, which President Eisenhower ordered, are three top governmental officials—John A. McCone, chairman of the Atomic Energy Commission; Arthur Flemming, Secretary of Health, Education, and Welfare; and Maurice Stans, director of the Budget Bureau.

One of the principal issues to be decided is whether the major responsibility for radiation protection should continue to be exercised by the Atomic Energy Commission or be transferred to the Public Health Service, a unit of the Department of Health, Education, and Welfare. When the study is completed, Stans, who is directing it, will submit recommendations to the President for organizing the governmental activities for radiological protection.

New AAAS Newsletter

The first issue of a new AAAS bulletin, titled *Science Education News,* was distributed last month to members of the scientific community. Publication of the six-page bulletin, which is to be issued quarterly, is an activity of the Science Teaching Improvement Program conducted by the association with the support of the Carnegie Corporation.

Charlotte Colton of Washington, formerly associated with the U.S. Department of Agriculture, in the capacity of science editor, has been appointed editor of the newsletter. She will be assisted by an advisory board of contributing editors, representative of various scientific societies. It is the present plan of the advisory board to devote each quarterly issue to a special phase of science education. This first issue, however, is more general in nature and includes editorial statements written by the contributing editors on the needs in science education and the reasons why their respective societies are involved in extensive education programs. The fall issue probably will be devoted to teacher-education programs. Other topics suggested for later issues are the use of moving pictures and television, curriculum studies, and visiting-lectureship programs. In addition to key articles on a particular theme, each issue will contain brief announcements and notices on science education.

Immortals of Science

Final selection of the world's 25 "Immortals of Science," whose names will be permanently inscribed on the Science Wall of Honor at the University of Bridgeport, has been announced by James H. Halsey, president of the university. The names of the 25 scientists selected will be permanently inscribed on the limestone walls of the university's $1,400,000 Charles A. Dana Hall of Science, now under construction. The building will be completed in January of 1960.

Selected as "Immortals of Science" and listed in chronological order are: Hippocrates, 460–357 B.C.; Aristotle, 384–322 B.C.; Euclid, 330–275 B.C.; Archimedes, 287–212 B.C.; Leonardo da Vinci, A.D. 1452–1519; Nicolaus Copernicus, 1473–1543; Galileo Galilei, 1564–1642; Johannes Kepler, 1571–1630; Sir William Harvey, 1578–1657; René Descartes, 1596–1650; Robert Boyle, 1627–1691; Sir Isaac Newton, 1642–1727; Joseph Priestley, 1733–1804; Antoine Laurent Lavoisier, 1743–1794; Karl Friedrich Gauss, 1777–1855; and Michael Faraday, 1791–1867.

Also, Charles R. Darwin, 1809–1882; Gregor J. Mendel, 1822–1884; Louis Pasteur, 1822–1895; James C. Maxwell, 1831–1879; Robert Koch, 1843–1910; Wilhelm K. Roentgen, 1845–1923; Max K. E. L. Planck, 1858–1947; Marja Sklodowska Curie, 1867–1934; and Lord Ernest Rutherford, 1871–1937.

Newton polled the most votes in the world-wide election; he was followed closely by Pasteur. Galilei, Darwin, M. Curie, Archimedes, Copernicus, Faraday, Mendel, and Aristotle complete the list of the ten scientists who received the most ballots.

The rules for making nominations for the Science Wall of Honor specified that recognition in all instances would be limited to accomplishments in the fields of natural science—not in philosophy, history, or the social sciences. The scientist must have made a fundamental discov-

ery regarding the laws of nature or have been responsible for an invention not based on a previously known fundamental law of nature. Discoveries were to be weighed in accordance with their general value to mankind and their contribution to man's fund of knowledge. Ballots were cast by 1116 electors from a total of 49 foreign countries and from each of the 50 states of the United States, in the world-wide election.

Bohr Speaks at Laboratory Dedication

Niels Bohr, the Danish nuclear physicist, was the principal speaker at the dedication, 25 June, of General Dynamics Corporation's new John Jay Hopkins laboratory of pure and applied science, outside San Diego, Calif. In a short address, Bohr spoke of the interaction between technology and science and of the technological demands that atomic physics has made. He said that the new laboratory has "most promising prospects" of meeting these demands.

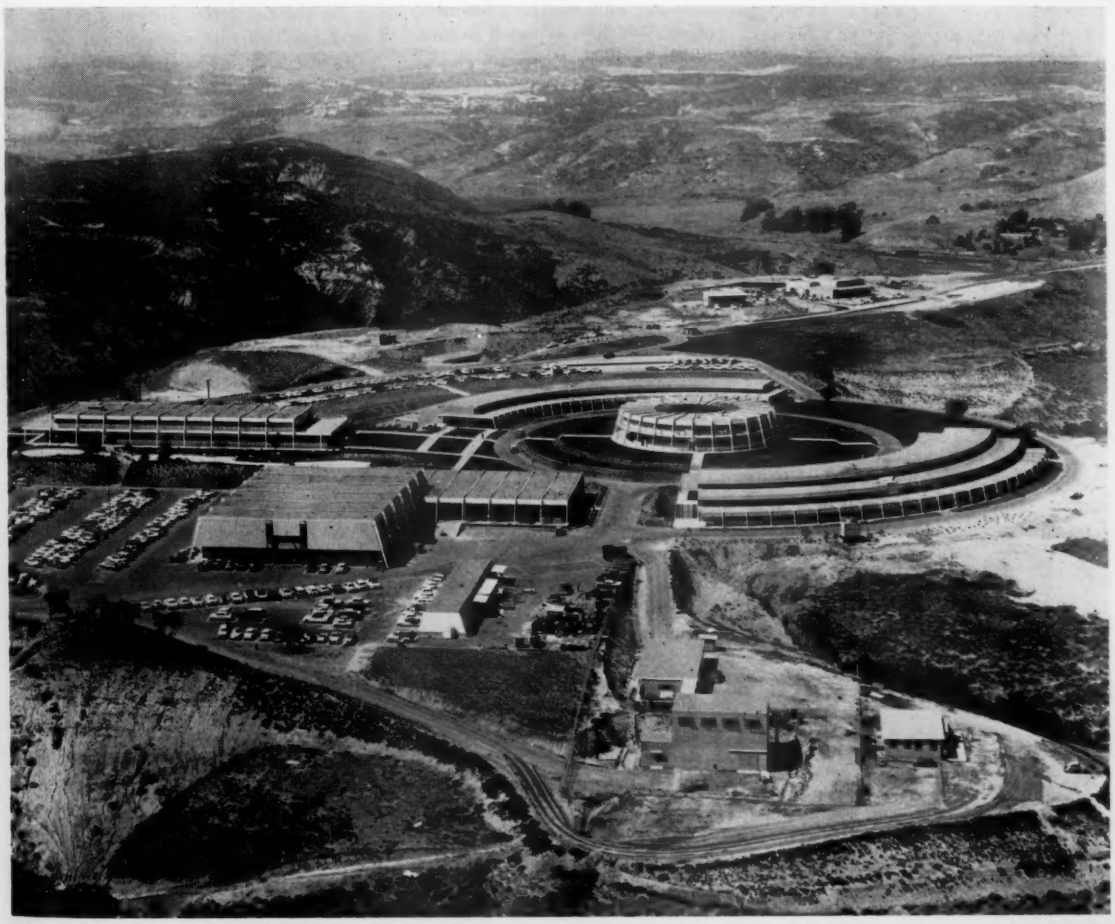
The laboratory, which is located on a 300-acre site just north of San Diego, has, in addition to the standard research center buildings, a building to house its reactor, a linear accelerator, a fusion research center, and a "hot cell" facility. In all, there are approximately 100 laboratories in the group. In a demonstration at the dedication ceremonies, the power output of the reactor, located at the north end of the site, was increased from 1 watt to 1 million kilowatts in less than 0.1 second. The actual flash lasted approximately 0.015 second. The self-regulating feature of the reactor's fuel-moderator elements of uranium and zirconium hydride immediately reduced the power to normal operating levels.

Among the many messages read at the ceremony was one from President Eisenhower, in which he sent congratulations to General Dynamics and continued:

"I hope that your new laboratory will be the home of many original and challenging ideas, concepts and products, and that it will fully realize the great potential you visualize for it."

Scripps Vessel Sails for 2-Year Study

The research vessel *Stranger* of Scripps Institution of Oceanography has sailed for Thailand, where the institute will conduct a 2-year oceanographic program under the auspices of the Thai and Vietnam governments and the U.S. International Cooperation Administration. The ship will be based in Bangkok. The scientific leader of the expedition is Anton Brunn, Danish zoologist, who was leader of the Danish round-the-world *Galathea*



Aerial view of General Dynamics Corporation's John Jay Hopkins laboratory for pure and applied science, San Diego, California. The new facility, named for the corporation's founder, was dedicated 25 June.

expedition. Brunn will be joined by other scientists in Thailand.

The purpose of the expedition is twofold: (i) to conduct oceanographic and marine biological surveys of the Gulf of Thailand and South China Sea, particularly with a view to assessing potential food resources of the area, and (ii) to train scientists from several countries in Southeast Asia in the techniques of oceanography. The Gulf of Thailand and the adjacent portion of the South China Sea comprise the largest semienclosed body of shallow ocean water in the world. In an area of 200,000 square miles, the water is nowhere deeper than 600 feet.

Chinese Translation Program

The National Science Foundation will begin next year to translate many of the scientific and technical journals that are published in Communist China. The projected program is part of an attempt to avoid being caught short on Chinese scientific advances, according to Burton W. Adkinson, head of the foundation's Office of Scientific Information. The program will start with the translation of two or three journals and will be expanded in future years.

According to a survey by the foundation, about 450 scientific journals are published in Communist China. More than 200 of these are now being received by government libraries in Washington, such as the Library of Congress. Most are untranslated, according to Adkinson.

There has been a very significant increase in scientific activity in China, according to many reports. It is said, for example, that the number of research institutes connected with the Chinese Academy of Sciences has doubled since 1952. The new NSF program will be designed to translate the most important journals originating in the 68 institutes.

Plans for Mohole Advanced

The Mohole project, a plan to drill into the boundary between the earth's crust and mantle, has been advanced recently by a decision of the Council of the National Academy of Sciences-National Research Council. The council has authorized the AMSOC Committee, which is in charge of the project, to accept responsibility for organizing and conducting the operations connected with the project. Before the decision, the committee's activities were limited to feasibility studies. The chairman of the AMSOC Committee, Gordon Lill, and the technical director, Willard Bascom, have reported that the studies have indicated that the project is both "feasible and highly desirable." The report continues: "The feasibility of drilling to the mantle depends on two things: (i) the depth to the Mohorovicic discontinuity, and (ii) the maximum reach of drilling tools. . . . We find that there are places both in the Atlantic and the Pacific basins where the total distance from the water surface to the mantle is less than 9.5 Km. (about 31,000 feet). We also find that leading members of the oil industry believe that 'a 50,000-foot hole would be possible if there were any reason to drill it and if the best of deep-drilling equipment and technology were assembled.' (the deepest hole to date is 25,340 feet)."

A tentative schedule issued by the committee calls for completion of the project, which is expected to cost $15 million, by 1962.

In another development, Columbia University recently received a grant of $30,000 from the National Science Foundation to support a site survey for the Mohole project.

News Briefs

The Air Force Research and Development Command has announced the successful development of a new information machine which reads typewritten pages and translates them into electrical signals at the rate of 200 characters per second. The new machine, the first of its kind, is called a print reader.

* * *

The Executive Board of the National Council on the Participation of Women in Science [see *Science* **129**, 1117 (1959)], at a meeting in Philadelphia on 20 June, voted to disband.

A new organization, the American Council on Women in Science, is being formed, with Mary Louise Robbins, professor of bacteriology at the George Washington University School of Medicine, Washington, D.C., as acting chairman. Other charter members include: Mrs. Ethaline Cortelyou (Aerojet-General Corporation, Atlantic Division, Frederick, Md.); Irene Corey Diller (Institute for Cancer Research, Philadelphia, Pa.); Dorris Hutchinson, (Sloan-Kettering Institute for Cancer Research, New York); Betty McLaughlin (consultant in pharmaceutical chemistry, Washington, D.C.); and Ernestine B. Thurman (Division of Research Grants, National Institutes of Health, Bethesda, Md.).

* * *

The establishment of a new department of virology on the Berkeley campus of the University of California has been announced. The department is one of the first in any major university in the world to be dedicated to the study of viruses. It will be closely associated with the 10-year-old virus laboratory on the Berkeley campus.

* * *

A number of kinds of radiation equipment will be supplied free of charge to the Government of Brazil, the International Atomic Energy Agency has announced. The equipment includes ionizing chambers of various types, Geiger and scintillation counters, radiation monitors, and dosimeters.

These materials are being provided in connection with the technical assistance the agency is giving Brazil to enable it to set up a service to carry out precise measurements of radioactivity and radiation doses in connection with the purchase, distribution, and use of radioactive material. The equipment supplied will be utilized by the National Institute of Technology of the Ministry of Labor, Industry, and Commerce and the Institute of Biophysics, Faculty of Medicine, University of Brazil.

* * *

The effectiveness of electronic devices and other equipment as aids in the teaching of science and mathematics is the subject of a major research study currently being made at Ohio State University. For purposes of the study a mobile laboratory has been designed which will contain closed-circuit television equipment, film-strip and motion-picture apparatus, a van de Graaf generator, and various demonstration devices. Grants in support of the $100,000 project have been made by the U.S. Office of Education, the Battelle Memorial Institute (Columbus), and Ohio State University.

* * *

A summer program for high-school science students is being offered at the New York Botanical Garden, 6 July–7 August, under a grant from the National Science Foundation. The program, designed for high-school students of high ability, will include classroom lectures, laborator work, and research, at the college level.

Scientists in the News

In a special ceremony held 29 May in Paris, EMIL WITSCHI, professor of zoology at the State University of Iowa, was honored by his French colleagues. He had been visiting professor at the University of Paris for the previous 3 months. The ceremony was held after the annual meeting of the French Society of Zoologists, at which Witschi gave the opening address. The professor, who is president-elect of the American Society of Zoologists, was then presented with a special volume of *Archives d'anatomie microscopique et de morphologie expérimentale.*

E. HAROLD HINMAN, dean of the School of Medicine–School of Tropical Medicine of the University of Puerto Rico and head of the department of microbiology, has been appointed chief of the Technical Resources Branch of the Public Health Division of the International Cooperation Administration. JOSE R. VIVAS, former director of the Gorgas Hospital, Ancon, Canal Zone, will succeed Hinman.

IRVING G. KAGAN, chief of the helminthology laboratory of the U.S. Public Health Service's Communicable Disease Center, Atlanta, Ga., is spending 1 month (15 June–15 July) as technical adviser to the World Health Organization, Geneva, Switzerland.

E. M. CRALLEY, head of the plant pathology department of the University of Arkansas College of Agriculture and Home Economics, has been appointed director of the Agricultural Experiment Station, which is affiliated with the university. He succeeds JOHN W. WHITE, who recently was appointed vice president for agriculture.

JANE CONNOR, research chemist at Michigan State University, has been appointed research project leader at the Evans Research and Development Corporation's radioisotope laboratory, New York.

LEE P. WITNAUER, physical chemist at the Eastern Utilization and Development Division, U.S. Agricultural Research Service, Wyndmoor, Pa., has received a $1000 award from the American Leather Chemists Association for a paper on the dynamic electrical behavior of untanned hide containing sorbed water.

The following individuals have recently received honorary degrees:

CHARLES W. BAULKNIGHT, senior research scientist at the Missile and Space Vehicles Department of General Electric Company, Philadelphia, Pa., from Johnson C. Smith University, Charlotte, N.C.

K. ROALD BERGETHON, president of Lafayette College, from Lehigh University.

JOHN T. CONNOR, president of Merck and Company, from Philadelphia College of Pharmacy and Science.

WILLIAM L. CRUM, professor of economics emeritus at the University of California, Berkeley, from the University of California.

LOREN C. EISELEY, professor of anthropology at the University of Pennsylvania, from Western Reserve University.

STANHOPE BAYNE-JONES, technical director of research for the Army Medical Research and Development Program in the Office of the Surgeon General, from Western Reserve University.

JOHN R. MAYOR, director of education, AAAS, from Knox College.

ELMER V. McCOLLUM, professor emeritus of biochemistry at the Johns Hopkins University, from Brandeis University.

AGNES F. MORGAN, professor of nutrition emeritus at the University of California, Berkeley, from the University of California.

RALPH T. OVERMAN, chairman of the Division of Special Training of Oak Ridge Institute, from Philadelphia College of Pharmacy and Science.

FRED SEARLS, JR., president of the Newmont Mining Corporation, New York, from the University of California, Berkeley.

LEANDER S. STUART, principal bacteriologist with the Agricultural Research Service, U.S. Department of Agriculture, from Philadelphia College of Pharmacy and Science.

JOHN A. WHEELER, professor of physics at Princeton University, from Western Reserve University.

CARL J. WIGGERS, professor emeritus of physiology at Western Reserve University, from Western Reserve University.

The University of Kentucky alumni association has awarded $500 to each of the following scientists for distinguished scholarship during the last two years. HERBERT P. RILEY, head of the botany department; MORGAN SCHERAGO, head of the bacteriology department; VINCENT F. COWLING, professor of mathematics and astronomy, and BERNARD B. KERN, professor of physics.

WILLIAM C. KNOPF, assistant director of research at International Minerals and Chemical Corporation, has been named technical director of the United States Industries Technical Center, Pompano Beach, Fla., research and development division of U.S. Industries, Inc.

Recent Deaths

CHARLES M. B. CADWALADER, Philadelphia, Pa.; 74; retired in 1950 as president of the Academy of Natural Sciences of Philadelphia, after having served the academy for 25 years; financed and installed the Audubon Bird Hall and the Hall of Earth History; 18 June.

ROBERT C. COLWELL, Morgantown, W.Va.; 75; professor emeritus of physics at West Virginia University; had been affiliated with the university since 1924; holder of many patents in the fields of electricity and radio; 10 June.

ALFRED R. MACORMAC, Waverly, Ala.; 64; associate professor of textile chemistry at the School of Home Economics of the University of Alabama since 1955; textile chemist with the U.S. Department of Agriculture, 1949–55; textile technician with the Army Quartermaster Corps, 1942–49; had been professor of textile chemistry at Clemson College and Alabama Polytechnic Institute and chief chemist at the Textile Products Company of Greenboro, N.C.; 13 June.

ERNST P. NEUSCHWANDER, St. George, N.Y.; 79; retired civil engineer, who had worked on the construction of New York's Triborough Bridge, Lincoln Tunnel, and Holland Tunnel; 2 June.

INNA V. POIRE, Washington, D.C.; 69; geologist with the United States Geological Survey; was geologist with the Geological Survey of the U.S.S.R. from 1925 to 1940; 10 June.

LYDIA B. WALSH, Oradell, N.J.; 54; professor of botany and chairman of the Division of Natural Sciences at Elmira College, N.Y.

JULIUSZ ZWEIBAUM, Warsaw, Poland; 72; professor of histology and embryology at the University of Warsaw; 6 May.

Book Reviews

A Diderot Pictorial Encyclopedia of Trades and Industry. Manufacturing and the technical arts in plates selected from *L'Encyclopédie, ou Dictionnaire Raisonné des Sciences, des Arts et des Métiers* of Denis Diderot. Edited with an introduction by Charles Coulston Gillispie. Dover, New York, 1959. 2 vols. xxx pp. + 485 plates. $18.50.

Ever since scholarship has flourished, its ogre and goddess has been "the literature." The 17th century saw the birth of the scientific journal, the invention of the device of the scientific paper, and the cumulative growth of the sciences whose accretion was facilitated by this means. The 19th century saw the advent of the abstracting journals whose function it was to provide a palliative for the flood of reading matter which was even then beginning to overpower the man at the research front.

Between these periods, in the 18th century, came the era of the encyclopedia, the consolidation of the corpus of knowledge. The world had had its encyclopedists since classical times and through the Middle Ages, but during the 18th century the spread of printing and the urge toward rational systematization produced efforts of a new order of magnitude. A surprisingly large number of these early encyclopedias have survived through many editions and are still with us. Head and shoulders above all the others, especially in its treatment of science and technology, was the *Encyclopédie* of Diderot.

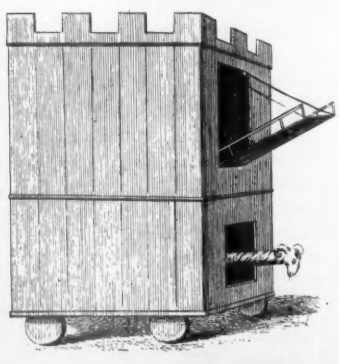


Fig. 1. An obsolete assault tower (plate 74 of the *Diderot Encyclopedia*). Notice that "battering ram" is a metaphor taken literally by the military engineers of early times.

It is well known how devastatingly effective Diderot's writings were as propaganda for his liberal ideology. His most ingenious scheme, however, was to make the Baconian examination of the trades, arts, and technologies in the *Encyclopédie* carry the ideology with it. By methodically examining and recording the tools and methods, the trades and machines, he dignified the craftsmen and emphasized the technological implications of a science that had previously been dominated by mathematics—a study which was the province of only the few, not accessible to the multitude.

Out of these circumstances, of "the literature" and the Enlightenment, came the *Encyclopédie*. Its preoccupation with science and technology was served superbly well by the art of the copperplate. In all, the *Encyclopédie* and its *Supplement* included 12 volumes containing 3129 plates. These constitute an entire "science museum" of illustrations—a museum containing panoramas of each sort of workshop and industry, with exhibits showing each device in such meticulous detail that we could reproduce it completely. By dipping into these large volumes of plates one can visit this frozen museum and recapture almost anything one seeks from the period.

This outstanding archive of illustration has long been familiar to those concerned with the history of science and technology. It provides that sort of pleasurable experience in which the hours slip by as one browses deeper into sections utterly irrelevant to one's immediate purpose. The complete set is far too rare, too costly, too large for most people to have on their own bookshelves. Even a reprinting of the volumes of plates alone would have been prohibitive in cost. The next best thing was to make a selection of the more appealing plates. That is what we have here—a choice of about one plate in six from the main work. This is the type of book which publishers say has "real estate value." One needs to own it and have it on the shelves for browsing and occasional use.

One cannot pretend that this selection will be very useful to scholars. Anyone who needs to refer to the *Encyclopédie* must have the full quota of plates and the original text. It is evident, however, that these two volumes will introduce many students and amateurs to a work that might otherwise rest unseen in the rare book room of the library. For this purpose the very well-written editorial introduction is most fitting, though the detailed notes on trades and on individual plates tend to be minimal. Probably, however, Gillispie has shown his usual good taste here; the main thing is the plates. One wishes only to know what they illustrate, not to have a lecture on each technology and trade.

The selection of plates for the anthology was based on artistic value and human interest. This seems a reasonable basis of choice, and to concentrate on the trades and industry side of the *Encyclopédie* seems reasonable too. I would, however, have liked to see science also represented in the selection through inclusion of a few pictures of scientific instruments and apparatus.

Technically the reproduction seems good (if one does not lay these volumes next to the originals), though the brilliance of the copperplates might have been better preserved by using a less yellow paper and thus increasing the contrast. The volumes are handsome, and one must give great credit to Dover Publications for instigating this lavish effort as a complement to the revolution they have been effecting in more workaday areas in the book-using habits of scientists.

DEREK J. DE SOLLA PRICE
School of Historical Studies, Institute for Advanced Study

The Evolution of North America. Philip B. King. Princeton University Press, Princeton, N.J., 1959. xvii + 190 pp. Illus. $7.50.

This volume is a very notable production by Philip B. King, a principal geologist on the staff of the U.S. Geological Survey. It is the outcome of the author's long interest in the regional

geology of North America. The emphasis is on the development of the structure of the outer shell of North America, rather than on its stratigraphy, its paleontology, or the origin of its land forms.

The book deals, in the main, with southern Canada and the United States (exclusive of Alaska), because that portion of North America is geologically best known. Moreover, regions that are thought to illustrate principles of continental evolution or stages in that evolution have been selected. The author, therefore, warns the reader that he is likely to discover that some favorite area of his is not discussed.

The book comprises nine chapters. Each chapter closes with a short list of references, mainly of the more recent literature. These lists are not exhaustive but "represent reading in which the author himself found pleasure, instruction, or stimulus."

The idea that the North American continent has undergone a steady evolution dates back to James D. Dana. "The scheme of progress even to minor details dates from the beginning. . . . Tracing out the development of the American continent from these Archean beginnings, is one of the main purposes of geological history." In short, Dana's hypothesis was that the continents, beginning from old nuclei, grew by successive additions, on their borders, of folded geosynclinal belts more and more recent in age. This idea is still widely held. King's view, which is similar, is given briefly in chapter 1 (pages 7–8); it is that the continental plate was built outward from a nucleus over the original underlying layers of basic rock ("sima"). However, the idea of an evolutionary growth of North America is not developed *in extenso* or presented in chronologic sequence.

In contrast, Kuenen in 1950 bluntly stated that the widely held idea on continental growth "does not meet the facts." The folding of a geosynclinal tract, according to Kuenen, instead of enlarging a continent, actually thickens and narrows a belt that already belongs to the continent. Such opposing hypotheses manifestly require further examination.

In a remarkably frank statement in the preface of the book King declares that the work is not "a textbook in the usual sense. . . . It is avowedly 'slanted' in directions of his [King's] current thinking, and contains willful prejudices and outrageous hypotheses, some of which may not stand the test of time. These prejudices and hypotheses would certainly corrupt the tender minds of undergraduate students and uninitiated laymen as no textbook should do." To ameliorate this harsh judgment, which implies a complete negation of the scientific method, it is but fair to point out that *outrageous hypotheses* is used in the William Morris Davis sense of meaning hypotheses that were considered completely unreasonable but eventually became orthodox doctrine [*Science* **63**, 463 (1926)].

In conclusion, geologists will find this volume, within the limitations indicated, to be a remarkably interesting and valuable synthesis of the regional geology of North America.

ADOLPH KNOPF
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The House of Intellect. Jacques Barzun. Harper, New York, 1959. viii + 276 pp. $5.

It is fashionable to feel uneasy about education and to have a sense of disquiet about the status of educators, scholars, and intellectuals. College presidents are coming out of their mendicant stoop and looking their constituency in the eye. Scientists speak up, are heard, and get money. *The House of Intellect,* by Jacques Barzun, is good medicine for the uneasy minds and for the self-confident ones.

His "Intellectual"—aggressively capitalized—is not simply the educator or the scholar. He is broadly defined through comparison with the artist and the scientist. More specifically he is the critical, discriminating, and clarifying mind, not imprisoned within a narrow speciality but with access to the broad fields of human knowledge. For different reasons the artist, the scientist, and the professional specialist are enemies of, or obstacles to, "the Intellect." The artist is the enemy of the Intellect because of such things as art's revulsion from words, from coherence, and from a normal and clear portrayal of the real world. Thus, art provides imprecision in language and distortion in thought and lets good taste and discrimination founder in inconsistent, arbitrary, and eccentric forms of expression. Science is the enemy of the Intellect because it has broken up the unity of knowledge and has favored a high-walled disciplinary separateness. Finally, the pervasive American spirit of philanthropy—which is the parent of mass education, of the right of equal entry for other forms of knowledge into education—is the enemy of the Intellect because it corrupts judgment, makes it difficult to insist on quality and success as established by rigorous standards of measurement.

Each reader will find his own favorite chapters in this aggressively written book. Two chapters, "Education without instruction" and "Instruction without authority," are required reading for all who seek some of the explanations of why American education may be failing to meet the challenge by which it is faced. The underpayment of the teacher and the underemployment of the pupil are only the first of these.

Each reader will also find cause for irritation and disagreement. Barzun is clearly unfair to the scientist in failing to recognize that some of the characteristics of new scientific fields, especially the submicroscopic ones in biology and physics, do not lend themselves to easy communication. In these, essential understanding is available only to small, specially trained corps of experts. Sometimes Barzun descends from helpful criticism to mere faculty-club chitchat without seeming to notice the difference. There are statements on the letting of scientific research contracts that are simply not true.

This is a book of nuggets; the reader must do a lot of his own panning to get them out, but it is worth while.

C. W. DE KIEWIET
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Progress in Biophysics and Biophysical Chemistry. vol. 8. J. A. V. Butler and B. Katz, Eds. Pergamon, New York, 1957. viii + 409 pp. Illus. $17.50.

Volume 8 in this series will be as useful as the previous volumes to specialists and advanced research workers in physiology. One must agree with the editors of this informative collection that here is something for all tastes. Among the best chapters are one by R. H. Smith on the biosynthesis of connective tissue components, which emphasizes the important role of ascorbic acid in the formation of collagen, and one by F. O. Schmitt and N. Geschwind on axon surfaces and the problem of neuronal junctions. Likewise, I. C. Whitfield has contributed a superb summary of the physiology of hearing. But other sections do not meet the same standard of organization.

It is, of course, understandable that

physicists are attracted to chapters with titles like "Color vision," "Electrical charges on bacterial surfaces," "Radiation effects on DNA synthesis," "Nerve transmission," and "Sound wave reception." On the other hand, chemists tend to favor subjects such as "Biosynthesis of protein" and "The physical chemistry of DNA." Physiologists should approve highly I. M. Glynn's critique "Ionic permeability of the red cell membrane."

The editors, J. A. V. Butler and B. Katz, state in their preface, "There is no need to apologize for the diversity of this biophysical menu." They hope their collection will "help provide a meeting ground for all those scientists, who in spite of their very different methods of approach, are concerned with the applications of physical principles to biology." In my opinion, biophysics as a branch of science is still not very secure. In fact this volume could, with seemingly equal justification, be issued under several other titles, such as "Recent Progress in Physiology," or "Recent Progress in Biochemistry," or simply "Progress in Biology." It is noticeable that many references are to work done before 1940. The illustrations are good but scanty.

WILLIAM R. DURYEE
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George Washington University

Ozeane Salzlagerstätten. Grundzüge der Entstehung und Metamorphose ozeaner Salzlagerstätten sowie des Gebirgsverhaltens von Salzgesteinsmassen. Hermann Borchert. Borntraeger, Berlin, 1959. 237 pp. Illus. DM. 48.

The Permian salt beds of central Germany have long been famous, not only as a source of potash but as a beautifully clear example of the usefulness of physical chemistry in the solution of geological problems. The painstaking work of van't Hoff and his colleagues, at the beginning of this century, on equilibria in saturated salt solutions made it seem probable that the history of the salt beds could be reconstructed in a fairly simple fashion, by the evaporation of enormous quantities of sea water under geologically reasonable conditions. Further investigation showed that this simple picture was inadequate, and during the past 50 years both chemists and geologists have tried to work out the necessary modifications. During this period, also, other extensive deposits of potash salts have been discovered—in England, Russia, the United States, and Canada—with characteristics even less consistent with van't Hoff's simple hypothesis. Inevitably, the subject has grown exceedingly complex and has been cloaked with a special nomenclature and a number of conflicting hypotheses that pose a formidable barrier to understanding by nonspecialists.

By far the best recent attempt to summarize current thinking on salt deposition is contained in a book published 2 years ago—*Steinsalz und Kalisalze,* by Franz Lotze. This volume is a comprehensive account of all kinds of salt deposits, and the space devoted to the German potash beds is necessarily limited. The author of the book under review explains in his introduction that he is setting out to amplify Lotze's treatment of marine deposits and to place in what he considers a fairer perspective certain theoretical ideas that Lotze passes over lightly. For the nonspecialist, therefore, the book is difficult reading because it assumes a knowledge of Lotze's previous work—as well as an intimate knowledge of German geography and geology. The book also taxes its readers' ability to maintain an unbiased viewpoint, because in it Borchert is frankly emphasizing the theoretical ideas which he considers important—ideas to which he himself has made fundamental contributions in a series of papers extending over many years.

In reconstructing the probable environment of original deposition of the German salt beds, Borchert envisions a time of hot-arid climate, when northern Germany was closer to the equator than it now is. The salts were laid down in a deep basin of partly stagnant water, much like the present Black Sea, separated from the open ocean by a series of bars and shallow lagoons; excessive evaporation in the basin caused inflow of sea water, the rate of inflow having changed from time to time in response to fluctuations of climate and to minor ups and downs of the bars. This reconstruction differs only in detail from the usual textbook picture. Some such mechanism for the addition of fresh sea water over an extended period of time has long been recognized as necessary to account for the extraordinary thickness of the salt beds.

The sequence of salts that would be expected as primary precipitates in this kind of situation can be worked out, as Borchert explains in detail, from experimental results on simple salt systems. The correspondence between prediction and mineral associations actually observed is sufficiently close so that the German salt beds were long taken as a classic example of primary precipitates only slightly modified after deposition. In detail, however, the sequence of salts departs in many respects from predictions based on experiment, and the discrepancies persist despite many attempts to modify the postulated conditions of precipitation. Probably most salt geologists would now agree with Borchert's conclusion that the Stassfurt beds look like a simple depositional sequence only by accident, and that other processes besides deposition from an evaporating brine must be invoked to explain their origin.

Borchert ascribes the lack of agreement between experiment and observation to three principal factors. First is the probability that strong temperature gradients existed within the basin of deposition, or between the basin and the marginal lagoons; such gradients, as Borchert himself has demonstrated experimentally, would lead to preferred deposition of different salts in the hot and cold areas and to broadening of the fields of stability for some salts. Second, burial of the primary salts beneath later sediments would lead to a rise in temperature and hence to progressive metamorphic changes in the salt minerals; Borchert differs from most other salt geologists in emphasizing the stepwise character of the metamorphism and in ascribing the metamorphism chiefly to fluids derived from the salts themselves—especially to water set free in the conversion of thick beds of gypsum to anhydrite. The third kind of change that affects the primary salt precipitates is "reverse" metamorphism brought about by dilute solutions from outside the salt beds, either surface water percolating downward or volcanic water coming from below. The variations in mineral association made possible by deposition in a temperature gradient and by the two kinds of metamorphism are so numerous that, in Borchert's opinion, a complete reconstruction of salt-bed history on the basis of physical chemistry and mineral association alone is impossible. Additional information can be obtained, however, from textures and from horizontal and vertical changes in mineral association, and by use of such data the history of any well-explored salt accumulation can be worked out.

Much of the book is devoted to examples of the application of these ideas to specific areas. The examples are taken

largely from the German salt deposits, about which a great wealth of descriptive information is available, but Borchert makes frequent allusions to potash deposits elsewhere for purposes of comparison. The treatment of many examples from different points of view makes the book seem repetitious, but the author is frank to say that the repetitiousness is deliberate. It does have the effect, as he hoped it might, of making his major ideas clearer and more forceful than they would be in a single statement.

The last part of the book is ostensibly a discussion of the mechanics of deformation of salt deposits. The emphasis, however, is chiefly on experimental work concerned with the deformability of salt crystals and crystal aggregates under a variety of conditions—experiments to which Borchert has made important contributions. Wisely, the author does not try to rival or to duplicate the excellent discussion given by Lotze of large-scale deformation structures in salt deposits.

One may object that the book in some measure belies its title, for it is certainly not a general treatise on marine salt deposits. One may question the author's seeming lack of generosity toward viewpoints that differ from his own—for example, "Failure to think through all these possibilities, combined with uncritical interpretation of field observations, still gives rise to endless discussions . . ." (reviewer's translation). One may wish, from the point of view of a foreign reader, that the author had described more fully the way various controversies have arisen and have developed. But within the limits of what he set out to do, Borchert has made a notable contribution to the literature on the origin of salt deposits. He has summarized his own work and his own ideas very clearly and has provided voluminous evidence for the correctness of his theories.

KONRAD B. KRAUSKOPF
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Stanford University

A Course of Pure Mathematics. G. H. Hardy. Cambridge University Press, New York, ed. 10, 1959. xii + 509 pp. Illus. Student's edition, paper, $3.75.

This book occupies a special niche in my heart, since it was used in the first course in mathematics that I attended as a graduate student, in 1917. That text was the first edition (1908), and the book under review is the tenth edition (1959). The book has been revised several times, but only in detail, to include newer concepts and proofs. The chapter titles and illustrations are intact, and so is the original flavor. Hardy always felt it necessary to defend the study of pure mathematics against those for whom mathematics is merely a tool; as this attitude was particularly prevalent in England in 1908, this book was written more or less in a spirit of evangelism. This tenth edition, now in its third printing, was brought out after Hardy's death in 1947 by several of his former colleagues at Cambridge University, among them J. E. Littlewood, and it is greatly to their credit that the enthusiastic style of the original has been preserved.

The book corresponds most closely with texts of advanced calculus in our American hierarchy of course titles, but one can learn much algebra and real and complex variable theory from it. It is 50 years old, and its hair is beginning to gray in places, but it is a fascinating book. With its wealth of problems, it is well suited to the needs of a student who must work by himself, without lectures. This, you must agree, is high praise.

C. C. MACDUFFEE
Department of Mathematics,
University of Wisconsin

The Aztec: Man and Tribe. Victor W. von Hagen. New American Library, New York, 1958. 222 pp. Illus. + plates. Paper, $0.50.

Mexico and the adjacent portions of Central America provided a varied geographical background for the development of an exceedingly interesting type of American civilization, which disintegrated under the impact of the Spanish conquest in the 16th century. Within the "Mesoamerican" region various subcultures have been distinguished by a combined archeological and ethnohistorical approach, the Maya and Aztec being the best known. The time period extends back to well before Christ.

Von Hagen's "paperback" undertakes to reconstruct Aztec culture, which appeared late, devoting suitable attention to its time-space relationships with its neighbors. It is planned for the general reader. The text is broken up into 32 short chapters, each with its own title, grouped under four major headings: "Historical and geographical background," "The people," "The Aztec 'kings' and directing classes," and "The achievements." In chapter 1 the author explains his long-time interest in ancient American civilizations and briefly reviews the roster of past contributors to our knowledge of these civilizations. He explains his approach thus: "In this book I, as author, have leaned heavily on much of this literature of the five centuries. I have attempted ('according to my character and idiosyncrasy,' to paraphrase the *Gardens of Epicurus,* 'of my own taste and fancy—in a word, as an artist') to select what I regarded as pertinent."

There are a good many literary allusions scattered through the text, as well as world-wide generalizations relative to specific Aztec traits which do not appeal to me, for my bias is that of an archeologist too close to minutiae. In general, the work seems acceptable as a popularization of the subject, and it does not seem to depart in important respects from the late George C. Vaillant's more or less standard *The Aztecs of Mexico* (1941). It is worth noting here that this is still readily available as a 1951 paperback reprint, with a "Postscript" by C. A. Burland on important archeological findings as of the reprint date.

I think that Vaillant's book will remain a better choice for textbook use. Its photographic coverage is much fuller, it provides a much more extensive bibliography, and there is a series of footnotes packed with sound scholarship. Von Hagen's "Bibliography and notes" provide valuable thumbnail descriptions of some 30 sources, but the notes seldom lead one to anything specific.

Human behavior is enormously complex, and in any such works as these inference and opinion lie behind much that must be, perforce, stated as fact, and a plain mistake or two is bound to creep in. The short chapter on the ancient calendar needs revision in this respect.

LINTON SATTERTHWAITE
University Museum,
University of Pennsylvania

The Onset of Stuttering. Research findings and implications. Wendell Johnson *et al.* University of Minnesota Press, Minneapolis, 1959. ix + 243 pp. Illus. $5.

The present volume is the latest in a long list of notable publications by its major author on the subject of stuttering. Johnson holds a position of preeminence in this field, and whatever he

chooses to publish will be read avidly by others interested in the same subject matter.

In this book Johnson and his associates report the findings of three research projects. Two of these are shown in great detail: the final 243 papes of the book are made up of tables of data indicating the responses to questionnaires of some 200 controls and an equal number of parents of stutterers. Such material is rarely made available in book form, and its value for the general reader is somewhat questionable; for those having an intense interest in the subject it is undoubtedly invaluable.

Two general findings are emphasized: the parents of stutterers are more demanding than others in their expectations regarding the fluency of their children, and they are somewhat more dissatisfied with their children and with each other, than the parents of nonstutterers are. These are certainly not surprising findings, but it is nice to see them stipulated so specifically. It has long been postulated that certain attitudes of parents toward their children cause tension states in the children; to see the relationship to stuttering so carefully drawn is extremely worth while.

The book includes a chapter devoted to what the authors call a "general interaction hypothesis" based on the research findings. As stated, this seems to support and implement Johnson's previously reported "semantogenic" theory of the cause of stuttering.

While it is limited in its appeal, the book is carefully written, claims no more for itself than its contents warrant, and makes available research data to indicate the source of its findings. It will undoubtedly find its place on most reference shelves in the sections reserved for worth-while books on speech problems.

J. M. WEPMAN

Speech Clinic,
University of Chicago

Just before Darwin: Robert Chambers and "Vestiges." Milton Millhauser. Wesleyan University Press, Middletown, Conn., 1959. ix + 246 pp. Illus. $4.50.

It has become almost a game to discover anticipations of Darwin's ideas and accomplishments. Indeed Darwin, like everyone else, had predecessors and built on the past, but until *The Origin of Species* was published there were almost no full-length, thoroughgoing, sufficiently documented publications on evolution in general or on particular theories of evolution. The nearest thing to an exception was *Vestiges of the Natural History of Creation,* issued anonymously in 1844 but now known to have been written by the Scottish publisher, encyclopedist, and hack writer Robert Chambers. In that remarkable work a dilettante perceived more clearly and sooner than most of the professional scientists the new direction that biology was taking at the time. Yet *Vestiges* was not basically or soundly a scientific or even a forward-looking production. It smacked rather, and in a somewhat half-baked way, of philosophical and theological predilections already obsolescent. (It is significant that the author was sympathetic, at least, to both phrenology and spiritualism.)

Chambers believed that the realm of natural law extends to living things and that evolution ("development") is among the universal natural laws. In that he was both right and progressive. But he mingled legitimate evidence with false data, naive arguments, wild speculations, and impossible theories. Darwin and Huxley, among many others, really were justified in acknowledging no scientific debt to Chambers. Nevertheless, *Vestiges* did make a contribution to the history of opinion, as distinct from that of ideas. In a later, more mellow mood Darwin eventually expressed well the real indebtedness. He still spoke of Chambers' "little accurate knowledge and. . .great want of scientific caution" but added that Chambers had "done excellent service. . .in calling attention to the subject, in removing prejudice and in thus preparing the ground" for general acceptance of the fact of evolution.

It is thus unwarranted to agree entirely with T. H. Huxley that Chambers' extravagances were a positive hindrance to the rise of evolutionary biology, or with a few later writers (for example, Lovejoy) that he should be regarded as a founder of that movement. His role was between those extremes, and it was minor. Yet it is an interesting and essential part of the drama. Millhauser's account is careful and fair. It gives particular attention to the climate of opinion and to the popular and literary antecedents and reactions. The biography of Chambers which is included is intellectual rather than personal, but it is adequate for the purpose. As an individual, Chambers remains a shadowy figure, but his ideas and influence have been well explored.

This is a welcome specialized addition to the wealth of new books on Darwin and his forerunners that are appearing in this centennial year of *The Origin of Species.*

G. G. SIMPSON

American Museum of Natural History and Columbia University

New Books

Australian Atomic Energy Symposium, 1958. Proceedings of a symposium on the peaceful uses of atomic energy in Australia held in Sydney 2–6 June 1958. Melbourne Univ. Press, Melbourne, 1959. 799 pp. The symposium was attended by 435 people, including 38 foreign representatives from Great Britain, the United States, Canada, New Zealand, Pakistan, and the International Atomic Energy Agency. A total of 114 papers were presented. They covered a wide range of interests in relation to raw materials, nuclear power, nuclear research, the basic sciences, education, and the industrial and medical uses of isotopes, and were divided into the following sections: "Materials"; "Power engineering"; "Power auxiliaries and research reactors"; "Basic sciences"; "Associated techniques"; "General." The appendices include a list of participants and a list of authors.

Automation: Its Impact on Business and Labor. John Diebold. National Planning Assoc., Washington, D.C., 1959. 73 pp. $1.

The Challenge of Science Education. Joseph S. Roucek. Philosophical Library, New York, 1959. 503 pp. $10.

Circumpolar Arctic Flora. Nicholas Polunin. Oxford Univ. Press, New York, 1959. 542 pp. $20.20.

The Orchids. A scientific survey. Carl L. Withner, Ed. Ronald Press, New York, 1959. 657 pp. $14.

Psychosomatic Methods in Painless Childbirth. History, theory and practice. L. Chertok. Translated by Denis Leigh from French ed. 2 of *Les Méthodes psychosomatiques d'accouchement sans douleur.* Pergamon, New York, 1959. 276 pp. $6.50.

Reproduction in Domestic Animals. vol. 1. H. H. Cole and P. T. Cupps, Ed. Academic Press, New York, 1959. 666 pp. $14.50.

Solid State Physics. Advances in research and applications. vol. 8. Frederic Seitz and David Turnbull, Eds. Academic Press, New York, 1959. 533 pp. $13.50. Contents: "Electronic spectra of molecules and ions in crystals. pt. 1: Molecular crystals," D. S. McClure; "Photoconductivity in germanium," R. Newman and W. W. Tyler. "Interaction of thermal neutrons with solids," L. S. Kothari and K. S. Singwi; "Electronic processes in zinc oxide," G. Heiland, E. Mollwo, F. Stockmann; "The structure and properties of grain boundaries," S. Amelinckx and W. Dekeyser.

Vector Space and Its Application in Crystal-Structure Investigation. Martin J. Buerger. Wiley, New York; Chapman & Hall, London, 1959. 366 pp. $12.

Reports

Delayed Hypersensitivity in Mice: Its Detection by Skin Tests and Its Passive Transfer

Abstract. Mice vaccinated intraperitoneally with a water-in-oil emulsion containing ovalbumin and avirulent tubercle bacilli developed strong immediate and delayed hypersensitivities, demonstrable by intracutaneous injection, to the ovalbumin. The two types of hypersensitivity could be differentiated by gross characteristics as well as by passive-transfer experiments with cells and serum from actively sensitized donors.

Recent work from several laboratories has challenged the long-held belief that mice cannot develop delayed hypersensitivity (*1, 2*). Unsuccessful attempts to evoke delayed-type skin reactions in presumably hypersensitized mice (*1, 3*) have caused slow acceptance of results from such experiments. Although reasons why these skin reactions have not been observed before now are not clear, the experiments reported below may contribute information toward eventual explanations as well as knowledge helpful to those using mice in experiments possibly influenced by delayed-type hypersensitivity reactions (*4*).

Twelve-week-old CF#1 white mice (Carworth Farms) were kept in small groups and supplied liberally with Rockland mouse diet and water. One set of 19 mice was injected intraperitoneally twice at weekly intervals with 0.1 ml of water-in-oil emulsion (*5*) containing 0.25 mg, moist weight, of living H37Ra strain tubercle bacilli and 0.25 mg of twice-crystallized ovalbumin (Nutritional Biochemicals Corp.). A second set of seven mice received similar injections of the emulsion alone. Two weeks after the second injection, all control and 15 test mice were challenged intracutaneously with 1 percent ovalbumin dissolved in physiologic sodium phosphate buffer at *p*H 7.4. This was done by anesthetizing each mouse with 1 mg of sodium secobarbital (Lilly) in 0.2 ml buffer, which was injected intraperitoneally, taping it to a glass plate so as to stretch the skin of the flank, clipping and shaving off the hair in this area, and injecting approximately 0.01 ml of ovalbumin solution just beneath the surface of the skin. This injection produced a bleb about 2 mm in diameter and 1 mm high which, in unsensitized mice, disappeared within about 30 minutes, leaving only a flat, blanched spot which usually persisted for at least 24 hours.

Reactions in actively sensitized mice were recorded in terms of induration diameter, relative skin thickening, and presence or absence of central necrosis. Twenty-four- and forty-eight-hour readings made in this experiment are shown in Table 1 and clearly differentiate test from control mice. The skin reactions resembled those of delayed hypersensitivity in guinea pigs mainly by the important common property of induration. Although spotty redness, apparently due to intracutaneous bleeding, also was common, there was no true erythema. Central necrosis was shallow, the affected area having an amber color and resembling wrinkled parchment. Preceding these apparent delayed-type reactions by several hours were strong immediate reactions peaking between 3 and 6 hours after challenge and then subsiding. They were characterized by edematous swelling as well as occasional petechiae.

Chase and others (*6*) have shown that delayed hypersensitivity can be transferred passively with lymphoid cells from hypersensitized donors but not with their antiserum which transfers only immediate hypersensitivity. Passive transfer of delayed hypersensitivity in mice has not been reported. An attempt at it seemed appropriate in enlarging upon the above observations.

Four mice of the sensitized group, saved from skin-testing to avoid possible desensitization, and five normal mice were used as cell and serum donors. Each donor was etherized lightly and then killed by bleeding from severed major armpit vessels, its blood being collected and pooled with that of other donors of a set. The clotted, pooled bloods from each set of donors were kept for 1 hour in a 37°C water bath for clot retraction, and then the serum was poured off and centrifuged free of blood cells at 500*g* for 15 minutes. One-tenth of a milliliter of serum was injected intraperitoneally into each of five normal recipient mice. Separate reversed passive cutaneous anaphylactic titrations in mice (*7*) showed 0.02 ml of 0.03125 percent test serum injected intradermally to be the lowest of a series of halving dilutions to react when 2 mg of ovalbumin was injected intravenously.

Immediately after a donor's blood had been collected, its rib cage was opened and its thymus gland and attached lymph nodes were removed. These tissues from each set of donors were pooled in 10 ml of Tyrode solution containing 0.0125 percent gelatin kept at 37°C and then homogenized in a medium-grind, large Ten Broeck tissue grinder by two slow, complete, twisting excursions of the plunger. The resulting homogenate was centrifuged at 500*g* for 15 minutes to sediment the cells, and most of the lightly turbid supernatant fluid was withdrawn and discarded, leaving 2.5 ml which was used to resuspend the cells for injection. Four-tenths of a milliliter of this suspension was injected intraperitoneally into each of five normal recipient mice within less than 1 hour after removal of the tissues from the first donor. Since in these preliminary experiments passively transferred activity was not meant to be equated with any particular type of cell and crude tissue homogenates were used, it is sufficient to state that each recipient was injected with 0.006 ml of packed tissue.

Recipients in the passive transfer experiment all were challenged intracutaneously with 0.01 ml of 1 percent ovalbumin, just as actively sensitized mice had been, serum recipients 24 hours and cell recipients 48 hours after passive transfer. Since both immediate and delayed types of reaction were expected, skin test sites were observed several

Table 1. Reactions in actively hypersensitized mice 24 and 48 hours after intracutaneous challenge with ovalbumin.

Group	Induration*	Skin thickening†	Central necrosis‡
	24 hours		
Control	0.1	0	0
Sensitized	5.3	2.5	9/15
	48 hours		
Control	0	0	0
Sensitized	3.9	2.0	9/15

* Millimeters mean diameter. † Times normal skin thickness. ‡ Proportion reacting.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

times during the first hour, and then at 3, 4, 5, 6, 24, and 48 hours after challenge.

In no case did recipients of normal serum or cells react to ovalbumin challenge. Mice receiving serum from sensitized donors developed edematous reactions of maximum mean diameter (10.6 mm) 3 hours after challenge, often accompanied by petechiae. These reactions lasted, somewhat diminished, through the sixth hour and had disappeared when the next (24-hour) reading was made. They never showed induration or necrosis. Hypersensitized tissue recipients, on the other hand, showed no reactions until the 6-hour reading, when induration, but no edema, was commencing. Induration continued to develop through the 48th hour when mean induration diameter was 1.6 mm and all mice showed central necrosis.

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References and Notes

1. F. R. Selbie and F. O'Grady, *Brit. J. Exptl. Pathol.* 35, 556 (1954).
2. D. F. Gray and P. A. Jennings, *Am. Rev. Tuberc. Pulmonary Diseases* 72, 171 (1955); F. O'Grady, *Brit. J. Exptl. Pathol.* 38, 319 (1957); D. F. Gray and M. N. Affleck, *Am. Rev. Tuberc. Pulmonary Diseases* 78, 226 (1958); A. J. Crowle, *J. Allergy* 30, 151 (1959).
3. B. Gerstl and R. M. Thomas, *Yale J. Biol. and Med.* 13, 679 (1941); P. D'A. Hart, D. A. Long, R. J. W. Rees, *Brit. Med. J.* 1, 680 (1952); C. B. Favour, *Proc. Soc. Exptl. Biol. Med.* 85, 237 (1954); P. Gastinel, A. Vaisman, F. Dunoyer, *Compt. rend. soc. biol.* 150, 237 (1956).
4. This work was aided by National Science Foundation grant G4025.
5. Physiologic sodium phosphate buffer (*p*H 7.4) : *n*-hexadecane : Arlacel A (10 : 4 : 1). Arlacel A (mannide monooleate) was a gift of the Atlas Powder Company, Wilmington, Del. See J. Freund, *Advances in Tuberc. Research* 7, 130 (1956).
6. See the recent review on this subject by B. H. Waksman, *Progr. Allergy* 5, 349 (1958).
7. Z. Ovary, *J. Immunol.* 81, 355 (1958).

23 March 1959

Paramyosin and Contraction of "Catch Muscles"

Abstract. The isotonic shortening of glycerol-extracted preparations of molluscan catch muscles is inhibited at *p*H's and ionic strengths at which extracted paramyosin crystallizes. The isometric tension development is hardly altered under the same conditions. Consequently, the "catch mechanism" is explained on the basis of the crystallization of paramyosin.

The unusual features of the mechanical responses and the metabolic activity of certain molluscan and annelid muscles led earlier investigators to postulate a "catch mechanism" (*1*) by means of which these muscles could remain contracted for long periods without a large expenditure of energy (*2*). These muscles can be brought into a condition which resembles a reversible rigor in isolated preparations also by the use of certain stimuli. Resistance to stretch is increased, and the muscle can sustain loads which exceed by several fold the maximal load which it can actively lift. The quick-release phenomenon is missing during this period (*3*). These muscles are also characterized by a periodicity revealed in small-angle x-ray diffraction (*4*) and electron optical studies (*5*). This unique fine structure has been attributed to the presence of paramyosin, a protein which, when extracted and viewed after drying and staining, has a great tendency to show periodic structures (*6*). Paramyosin has been obtained only from the so-called catch muscles, but its amino acid composition shows some similarities to that of proteins of the tropomyosin class (*7*) .

A connection between the presence of paramyosin and the "catch mechanism" is an intriguing possibility. In this report experiments are described which tend to support this view and which provide a model for the control of the elastic properties of "catch muscles" based on the behavior of extracted paramyosin.

For the preparation of paramyosin the adductor muscle of *Venus mercenaria* was blended for 1 minute in 0.1*M* KCl and washed three times in 20 volumes of 0.1*M* KCl. The residue was extracted in 3 volumes of 0.6*M* KCl, containing 0.04*M* *p*H 7.5 Tris buffer. To the extract 3 volumes of 95-percent ethanol was added. The precipitate was resuspended in 0.6*M* KCl containing 0.01*M* neutral phosphate buffer and dialyzed against 10 volumes of 0.6*M* KCl containing 0.01*M* neutral phosphate buffer. Paramyosin went into solution, while actomyosin, which is denatured by ethanol, remained insoluble, and was removed by centrifugation. Paramyosin was crystallized by dialyzing it against 6 volumes of 0.01*M* *p*H 6.0 phosphate buffer and redissolving in neutral 0.6*M* KCl. After recrystallization the protein was stored by lyophilizing it from 0.6*M* KCl solution.

For a second series of experiments, the anterior byssus retractor muscle of *Mytilus edulis* was prepared by removing the muscle, along with a piece of the shell, from the animal and stretching it slightly on a wooden frame. This unit was immersed in aerated sea water for 1 hour and then placed in a 50 percent (by volume) glycerol-water mixture at 0°C for 24 hours. These muscles were stored in 50 percent glycerol at −20°C for at least 2 weeks before use. Cell bundles 100 to 150 μ in diameter were stripped from the muscle for measurements of tension and shortening. Prior to these measurements, the bundles were

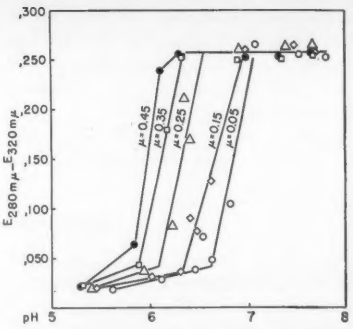

Fig. 1. Solubility of paramyosin. Paramyosin (0.9 mg/ml final concentration) was allowed to stand for 3 hours at room temperature. It was centrifuged, and the protein of the supernatant was measured by ΔO.D. 280 to 320.

equilibrated, first in 20 percent glycerol for ½ hour, and then for 15 minutes in an ATP-free solution of the desired ionic strength and *p*H. The fiber was finally transferred to the ATP-containing solution of identical *p*H and final ionic strength.

Crystallization is an outstanding property of paramyosin (*7, 8*). The protein forms needle shaped crystals—though with no faces and edges—in aqueous media which dissolve when the *p*H is changed by a relatively small amount. It was observed that a change of half a *p*H unit was sufficient to dissolve or reform the crystals (Fig. 1). The point of transition depended on the ionic strength, but stayed between *p*H 6 and 7.5 within the range studied ($\mu = 0.05$ to 0.45), shifting toward the acid side with increasing ionic strength. Neither 0.01*M* $MgCl_2$ nor 0.01*M* $CaCl_2$, when added to the solution, had a measurable effect on the solubility of the paramyosin. Adenosine triphosphate (4m*M*) increased the solubility at lower ionic

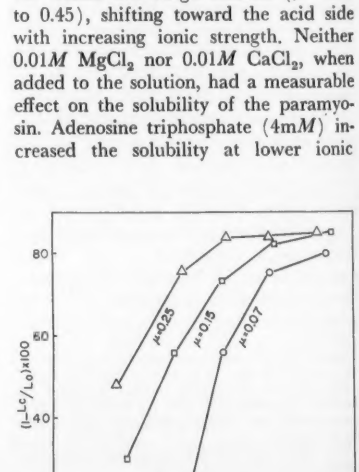

Fig. 2. Isotonic shortening of glycerinated preparations of anterior byssus retractor muscle of *Mytilus edulis*. Ordinate: *Lc*, contracted length; *Lo*, initial length.

strength ($\mu = 0.096$) and had no effect at the higher ones ($\mu = 0.15$ and 0.25) provided its contribution to the total ionic strength at various *p*H's is taken into account. The results were the same when histidine or acetate buffer was used in place of phosphate buffer. Crystallization of paramyosin thus appears to be most influenced by the *p*H of the solution.

The mechanical properties of "catch" muscles could be thus controlled by altering the *p*H of the medium. The control is simple and can be achieved under conditions which alter little the properties of actomyosin, since at low ionic strength the maximum tension and isotonic shortening of a glycerol-extracted psoas muscle fibril remains approximately constant between *p*H 6 and 7. If there is a connection between crystallization of paramyosin and the "catch" mechanism one would expect that the mechanical properties of glycerinated preparations of such muscles will show a *p*H dependence different from that of other muscles.

The isotonic shortening of glycerinated byssus fibers is greatly dependent on *p*H (Fig. 2). In solutions with a total ionic strength of 0.07, 0.15, 0.25, shortening is maximum above *p*H 6.7. Acidification causes a gradual inhibition. At *p*H 6.0 and ionic strength 0.07 the inhibition amounts to about 80 percent, while at higher ionic strengths inhibition occurs in more acid solutions. A comparison of the solubility curves of paramyosin and the data on isotonic shortening indicates that in conditions where paramyosin is crystallized shortening is inhibited. The correlation between cyrstallization and inhibition of shortening is reflected in the dependence on both *p*H and ionic strength. Fibers which failed to contract at low *p*H contracted readily when the *p*H of the solution was raised. Glycerol-extracted preparations of other catch systems, such as *Mytilus* adductor, *Venus* adductor—both tinted and white portions—*Ostrea* white adductor and *Pectin* white adductor, show essentially similar dependence of shortening on *p*H and ionic strength.

The inhibition of shortening was not caused by a reversible inactivation of the actomyosin system. The isometric tension did not show a considerable *p*H dependence and was nearly maximal under conditions where shortening was inhibited by about 80 percent. Thus one fiber developed 0.28 kg/cm² at *p*H 6.0 and another from the same bundle 0.32 kg/cm² at *p*H 7.2 at ionic strength of 0.07. Another fiber of the same bundle developed 0.42 kg/cm² tension at *p*H 6.0 and 0.25 ionic strength. There was, however, a difference in the rate of tension development at various *p*H's, the rate being greater at higher *p*H. Preliminary experiments on the *p*H-dependence of adenosine triphosphatase activity of breis prepared from glycerinated byssus muscles of *Mytilus* indicate that a peak occurs at *p*H 6.3 to 6.5 with little decline between *p*H 6.0 and *p*H 7.0. Although the optimal conditions for tension development in these preparations have not been worked out, the above results indicate little *p*H dependence of tension development, certainly not enough to produce up to 80 percent inhibition of shortening.

These experiments may be simply explained by assuming that actomyosin and paramyosin are at least functionally separated in catch muscles. The behavior of the actomyosin system does not differ much from the actomyosin system of other muscles. The different behavior of "catch muscles" could be explained by the presence of the paramyosin system, the crystallization of which "freezes" the muscle at any length or in any state, inhibiting shortening and increasing the resistance to stretch. It has been found recently that the 145-A periodicity, observed in electron micrographs, is predominantly associated with muscles in the catch state, suggesting that crystallization occurs in these muscles (*9*). In this way the tension developed by the actomyosin system may be preserved by the paramyosin system for an indefinite time without any further active process and without the need for a continuous expenditure of energy. In vivo, the two sytems may be activated independently and, even though it is not necessarily a *p*H variation which activates the catch system, it is of importance that essential features of the "catch mechanism" can be shown by glycerol-extracted preparations.

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References and Notes

1. J. von Uexkuell, *Z. Biol.* **58**, 305 (1912); W. M. Bayliss, *Principles of General Physiology* (Longmans, Green, London, ed. 4, 1924), p. 534.
2. J. Parnas, *Arch. ges. Physiol.*, Pfluger's **134**, 441 (1910); A. Bethe, *ibid.* **142**, 291 (1911).
3. W. H. Johnson and B. M. Twarog, in preparation.
4. R. S. Bear, *J. Am. Chem. Soc.* **66**, 2043 (1944); R. S. Bear and C. C. Selby, *J. Biophys. Biochem. Cytol.* **2**, 55 (1956).
5. C. E. Hall, M. A. Jakus, F. O. Schmitt, *J. Appl. Phys.* **16**, 459 (1945).
6. A. J. Hodge, *Proc. Natl. Acad. Sci. U.S.* **38**, 850 (1952).
7. K. Bailey, *Pubbl. staz. zool. Napoli* **29**, 26 (1956); K. Laki, *Arch. Biochem. Biophys.* **67**, 240 (1957).
8. R. H. Locker and F. O. Schmitt, *J. Biophys. Biochem. Cytol.* **3**, 889 (1957).
9. W. H. Johnson and D. E. Philpott, Abstracts of the Biophysical Society meeting, Pittsburgh, Pa. (1959), C-3.

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Contamination of the Air by Radioactivity from the 1958 Nuclear Tests in the Pacific

Abstract. By the use of bomb-produced tungsten-185 tracer, debris from the 1958 nuclear tests (Hardtack) held at the U.S. Pacific Proving Ground have been identified as they appeared in the ground-level air along the 80th meridian. A large amount of radioactivity from these tests appeared in South America, particularly at the high-altitude collecting stations.

The Hardtack series of nuclear tests in the Eniwetok-Bikini area afforded a unique opportunity to identify radioactive debris in the atmosphere which were associated with a known series of tests, since a number of nuclear devices exploded during that series contained tungsten which became activated by the intense neutron flux. This radiotungsten activity, then, served as a specific radioactive tracer for debris from this one series of tests.

Ground-level air-filter samples from 18 collecting stations located principally along the 80th meridian from Coral Harbour, Northwest Territories, Canada, to Punta Arenas, Chile, were analyzed by radiochemical techniques for β-emitting W^{185} and for a number of high-yield fission products, among them Sr^{90}.

Figure 1 shows the concentration of W^{185} activity in disintegrations per minute per 100 cubic meters of air (corrected to sea-level pressure) for the period of May–July 1958. Background samples collected at all stations during April 1958 showed that at that time there was no background activity of W^{185} in the atmosphere. The rapid spread of this activity is particularly noteworthy. By the end of May it was detected at 10 stations along the 80th meridian from Columbia, South Carolina (34°N), to Antofagasta, Chile (23°S). By the end of June, it was detected from Moosonee, Ontario (51°N) to Punta Arenas (53°S). In July, it appeared at Coral Harbour, (64°N), our northernmost station. The highest W^{185} concentrations appeared initially at the high-altitude sites of Chacaltaya, Bolivia (5220 m), Huancayo, Peru (3353 m), Quito, Ecuador (2818 m), and Bogota,

Colombia (2640 m). The only significant change in the activity pattern during this period was the increase in W^{185} concentration in the mid-latitudes of the Northern Hemisphere.

Both the high W^{185} activity and the high gross β-activity found in South America during the period May–July document the fact that one or more transfers of air from the Eniwetok-Bikini area into the Southern Hemisphere occurred. This is the first time that any appreciable quantity of radioactive matter from a known source in the Northern Hemisphere has been identified south of the equator.

In Fig. 2, plots of W^{185} relative to the gross fission-product β-activity (assumed to have an average β-energy of 1 Mev) are shown. It may be noted that even though debris from Hardtack appeared at a number of sites in the Northern Hemisphere, at only a few places did it contribute significantly to the total radioactivity present. The tungsten-containing debris was relatively more important during May and June at sites where the fission-product background was low, as at Miraflores, Panama Canal Zone, and Bogota, Colombia, above the equator and at most sites in the Southern Hemisphere.

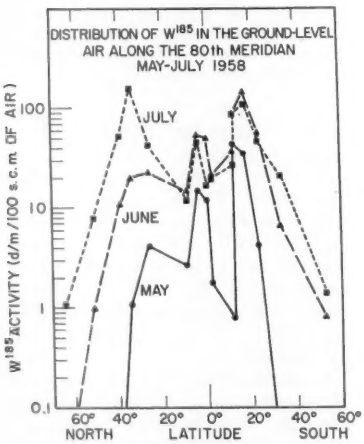

Fig. 1. Distribution of W^{185} in the ground-level air along the 80th meridian, May–July 1958.

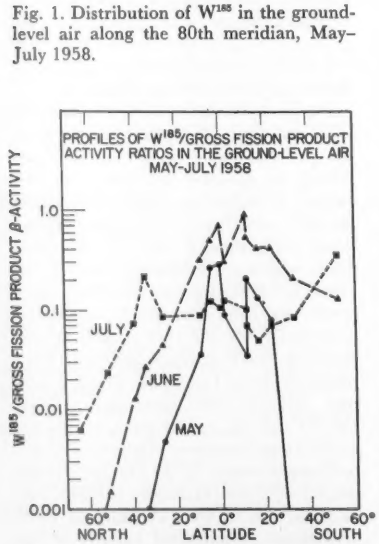

Fig. 2. Profiles of W^{185}/gross fission-product activity ratios in the ground-level air, May–July 1958.

At Lima, Peru, during June, the W^{185} activity was nearly as high as the gross fission-product activity. If a 1:1 ratio represents the relative values of these components of Hardtack debris during June, undiluted by fission products from other sources, the contribution of this debris to the activity in the air at other sites may be calculated. The fraction of the total activity due to the fresh debris at sites in the Northern Hemisphere decreases rather uniformly from 70 percent at the equator (Quito), to 30 percent at Miraflores, to 5 percent at Miami, Florida, and 1 to 2 percent at Washington, D.C. It is impractical to attempt a similar analysis for July because of the changes in this W^{185}/fission-product activity ratio through radioactivity decay and because of the influx of fresher debris having different amounts of tungsten activity. The different composition of the newer debris is evident in a comparison of the July data presented in Figs. 1 and 2. While at the sites between 10°N and 40°S latitude there was little change in the absolute quantity of W^{185} in the air, its activity relative to that of the gross fission products decreased markedly, indicating the presence of considerable radioactive material having a lower radiotungsten content. This was most evident at the sites which had previously had the highest W^{185} activity.

Results from the triad of stations at Subic Bay, Philippine Islands, and Pearl Harbor and Mauna Loa, Hawaii, are particularly interesting. Subic Bay, lying to the west of the test site, received a large amount of new debris in May, as is shown by increases both in the total β-count and in the W^{185} activity, but these decreased markedly during June. Pearl Harbor and Mauna Loa collected no tungsten-containing Hardtack debris during May. During June some of this material arrived at Pearl Harbor, but nearly 10 times as much appeared at the high altitude station of Mauna Loa (3394 m). This altitude difference was even more marked in July. Since no significant changes in Sr^{90} concentration occurred during this period, a rather stable background of old debris at these sites is indicated.

From the data presented here it is evident that fission products or other materials introduced into the atmosphere at a particular latitude do not necessarily remain in any restricted zone near that latitude but spread rapidly throughout the hemisphere. If such materials are introduced simultaneously on both sides of the equator, as happened in this case, rapid spread throughout both hemispheres occurs. The rapid spread of radioactive debris throughout the atmosphere of the Northern Hemisphere has been noted previously for a number of series of nuclear detonations in both Nevada and the U.S.S.R.

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30 April 1959

Phenotypic Effects of Heterozygous, X-ray-Induced Mutations in Drosophila

Abstract. Heterozygous mutations produced by 3000 r delay pupation in about 9 percent of larvae of *Drosophila melanogaster* under nutritional stress and kill approximately 6 percent. The effects are less, though appreciable, when there is excess nutrient; no effects are detectable after oögonia are irradiated. Irradiated sperm and oöcytes cause detriment, partly via different types of mutations, in approximately equal amounts.

In large cross-fertilizing populations, germinal mutations are usually present in heterozygous condition. Because of this it is desirable to determine, in the first generation receiving mutated genes induced by a large radiation dose, the nature and amount of the heterozygous effect, its dependence upon environmental factors, and its basis in chromosomal rearrangements and point mutations.

The specific aims of the present work (*1*) with *Drosophila melanogaster* were to study in F_1 larvae, some of which had been subjected to nutritional stress and some not, some of the heterozygous effects of eucentric rearrangements and point mutations induced by administration of 3000 r of x-rays (*2*) to sperm or to oöcytes and oögonia. The phenotypic effects studied were delay in pupation and failure to pupate.

Virgin yellow (*y*) females were mated to gray (y^+) males from an apparently unrelated strain. Males, when irradiated, were discarded after one day of mating. Females were permitted to oviposit on protein-deficient (sugar, agar, water) medium for ½ to 1 day; then they were removed, and the eggs were allowed to develop for 1 day into larvae. In this cross the sex of newly hatched F_1 larvae is easily distinguished, males having yellow mouth parts and females gray. In cases where larvae were to be

"fed," the medium was sown with live yeast. For each test, 100 newly hatched larvae (either males or females) were transferred to a bottle containing unyeasted protein-deficient medium (which included, in the second experiment, the mold inhibitor Tegosept-M).

In the first experiment, some P_1 males were irradiated and some were not. An excess of live yeast was added to the bottles either immediately after the larvae were transferred to them ("fed" series) or four days later ("semistarved" series). The number of larvae eventually able to pupate was determined.

The second experiment involved, besides unirradiated controls, males and 4-day-old, well-fed females which were irradiated and crossed to unirradiated flies. In addition to a "fed" series there was an "undernourished" series—one in which 6 mg of yeast was placed in each bottle prior to transfer of the larvae to the bottles, an excess of yeast being added 4 days later. The number of larvae that pupated by the 9th day after oviposition and the number that finally pupated were recorded.

Following irradiation of sperm, F_1 females have approximately a 20-percent greater chance to show heterozygous effects of point mutations than do F_1 males, since this is approximately the percentage by which X-bearing sperm exceed Y-bearing sperm in level of euchromatin. There may be, however, an equal or greater chance that Y-bearing as compared with X-bearing sperm will undergo rearrangement at fertilization or produce heterozygous position effects through rearrangement, or both. Differences in effect actually obtained in sons and daughters were not significant in six possible comparisons (of which four were independent of one another) and were equally frequent in both directions. The absence of a detectable sex difference is attributable to the fact that heterozygous effects of rearrangement are greater than those of point mutation of euchromatic genes.

In view of this, and of the fact that the number of tests in comparable unirradiated and irradiated series was almost exactly equal for a given sex, the results for sons and daughters of irradiated fathers have been combined in Table 1. As is shown there, irradiation of sperm caused 4 to 7 percent of the larvae to die prior to pupation. An additional effect—delay in pupation—is demonstrated by the larger number of larvae (approximately 9 percent) which had failed to pupate by the 9th day after oviposition.

When females are irradiated, mutations involving the X-chromosome are heterozygous in daughters but hemizygous in sons. Since hemizygous mutations produce more phenotypic effect than heterozygous ones, a difference in

Table 1. Results of tests on unirradiated and on x-irradiated (3000 r) male and female *Drosophila*.

Expt. No.	Nutrition*	F_1	No. of tests		Day No. 9		Final day	
			Unirradiated	Irradiated	Unirradiated†	Irradiated‡	Unirradiated	Irradiated
			P_1 males					
1	Fed	♀ + ♂	24	24			98.0 ± 0.4	−4.4 ± 0.7
1	Semistarved	♀ + ♂	23	24			94.6 ± 0.8	−7.2 ± 1.3
2	Fed	♀ + ♂	10	10	97.7 ± 0.5	−8.9 ± 1.1	97.7 ± 0.5	−5.8 ± 1.0
2	Undernourished	♀ + ♂	25	44§	92.9 ± 0.8	−9.3 ± 1.1	95.2 ± 0.7	−5.8 ± 0.9
			P_1 females					
2	Fed (4 + 6)	♂	5	8	97.4 ± 0.9	−6.7 ± 1.9	97.4 ± 0.9	−6.1 ± 1.2
		♀	5	7	98.0 ± 0.2	−4.7 ± 1.2	98.0 ± 0.2	−3.5 ± 1.1
2	Undernourished (2 + 3 + 5)	♂	10	12	92.7 ± 1.5	−8.7 ± 2.2	96.0 ± 1.3	−7.0 ± 1.8
		♀	8	14	93.1 ± 1.6	−8.3 ± 2.1	95.5 ± 0.7	−6.2 ± 1.5
2	Undernourished (7 − 13)	♂	15	15	92.1 ± 1.2	−4.1 ± 1.7	93.6 ± 1.0	0 ± 1.3
		♀	13	15	94.2 ± 0.7	−1.7 ± 1.2	95.6 ± 0.3	+1.0 ± 0.7

* Values in parentheses show the number of days after irradiation on which eggs were laid. † Mean percentage pupated, plus or minus mean standard error. ‡ Mean induced (irradiated-unirradiated/unirradiated) percentage lowered, plus or minus mean standard error. § Only 39 scored on day 9.

results between F_1 male and female larvae is expected. While the difference in effect obtained for F_1 males and females from irradiated mothers was not significant in 12 possible comparisons (of which six are independent), the values for sons were higher than those for daughters in every case (see Table 1); this demonstrates that there is a greater over-all effect in larval males than in larval females.

This sex difference cannot be attributed to the fact that sons are yellow and daughters are gray, since in the first experiment this difference was shown to have no effect. It is also not related to gross intrachromosomal and reciprocal interchromosomal rearrangements, which are so rare in the female germ line that the frequency of X-chromosome involvement is negligible. However, point mutations and half-translocations could, separately or together, account for the sex difference. The former produce hemizygous and heterozygous effects in sons and daughters, respectively; the latter produce hyperploidy (through cappings of X) and hypoploidy (through capturings).

Following irradiation of females, there was significant detriment in both son and daughter larvae from eggs laid during the first 6 days after mating. However, the final results for eggs laid on days 7 through 13 are not significantly different from those for the unirradiated controls and are significantly lower than those for comparable eggs laid on days 2 through 5. The 9th-day pupation rates for eggs laid on days 7 through 13, though they do not differ from those of the controls in the case of the daughters, show some effect of irradiation in the case of the sons, and the effects in both sons and daughters were significantly less than those for comparable eggs laid on days 2 through 5. These results correlate with those from other experiments, where similar females were irradiated. In these, half-translocation and recessive lethal mutation rates were significantly reduced among eggs laid more than 6 days after irradiation (usually oögonia when irradiated) as compared with eggs laid earlier (mostly oöcytes when irradiated).

One comparison between well-fed and nutritionally limited larvae gave statistical support for a difference in effect (experiment 1, well-fed versus semistarved larvae gave P approximately .05). Six other comparisons are possible (of which three are independent); of these, one furnished no test and five gave results in the expected direction. This demonstrates that nutritional stress enhances the detrimental effects of heterozygous mutations.

It can be calculated, on the basis of data for irradiated females for days 2 through 6, that point mutations in heterozygous condition could cause a maximum of about 2 percent mortality of larvae in these experiments. Since the x-ray-induced point mutation rates for sperm and for oöcytes are approximately equal, it is evident that nearly half or more of the detrimental effect found following irradiation of sperm results from reciprocal interchromosomal or gross intrachromosomal rearrangements.

It should be noted, finally, that at this dosage level the detriment to larvae is approximately equal following irradiation of sperm or oöcytes.

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References and Notes

1. This study was supported by a grant from the U.S. Atomic Energy Commission [contract AT(11-1) 633]. See also similar, independent, results of V. B. Crowell, *Drosophila Inform. Serv.* 32, 119 (1958).
2. Irradiation facilities were kindly provided by Firmin Desloge Hospital, St. Louis.

2 February 1959

Role of Water in the Stability of Oxyhemoglobin

Abstract. Electron exchange involving the valence states of iron occurs via water bridges. Molecular oxygen reversibly displaces the sole coordinated water of the ferrous iron in hemoglobin, and, in the absence of this ready path for electron transfer, the oxygen is transported without oxidation of the ferrous iron of hemoglobin.

The heme in hemoglobin combines reversibly with molecular oxygen without oxidation of the ferrous iron (*1*)

$$Fe_p^{II}(H_2O) + O_2 \rightleftharpoons Fe_p^{II}(O_2) + H_2O \quad (1)$$

while the ferrous iron of free heme is readily oxidized by oxygen. Because of the physiological importance of oxygen transport by hemoglobin, these reactions have attracted considerable attention, yet the causes of these differences in behavior have not yet been explained in an entirely satisfactory manner.

The hemes in hemoglobin are evidently buried within the protein molecule, and, as a consequence, the situation is complicated by the details of protein structure. Wang *et al.* (*2*) have suggested that the globin in hemoglobin partially screens the hemes with hydrophobic groups, thus tending to exclude water and altering the effective dielectric constant at the bonding sites. A hemoglobin model has been synthesized, and its properties have been studied in order to substantiate these views.

I have pointed out that processes in solution involving iron(III), and, by implication, iron(II), may be more dependent on specific solvation effects than on changes in the macroscopic dielectric constant (*3*). Furthermore, explanations which invoke the notion of the microscopic dielectric constant are inherently ambiguous since this concept is not amenable to direct experimental investigation.

Studies of the kinetics of the iron(II)-iron(III) electron-exchange reaction (*4*), especially in mixed solvent media (*5*), have yielded one conclusion relevant to the problem of the stability of oxyhemoglobin: that the 9- to 10-kcal/mole iron(II)-iron(III) oxidation-reduction process involves transfer of a single electron through waters of solvation. Electron transfer by alternative mechanisms is less favored energetically. This conclusion is supported by the observations that the iron(II)-iron(III) exchange does not occur in the absence of water (*5*), that the specific reaction rate constant goes through a maximum with increasing concentration of catalyzing, strongly-complexing anions (*6, 7*), that there is a pronounced deuterium effect (*8*), and that a cyanide ligand must be replaced by water in $Fe(CN)_6^{-4}$ before that species can be oxidized by hydroperoxides (*9*). Also, work on the iron(II)-iron(III) exchange, especially that of Hudis and Wahl (*6*) together with work on a multitude of other electron-exchange reactions, has clearly shown the absence of any systematic reactant charge-product dependency, and thus, presumably, the comparative unimportance of dielectric constant effects.

Now, in hemoglobin, four of the six coordination positions in iron(II) are occupied with the near-planar porphyrin system, one is occupied by the globin, and the sixth only is occupied by a water molecule (*1, 10*). This single water molecule, on the basis of the above arguments, must play a crucial role in oxidation processes, and when it is displaced, even by oxygen, no path will remain for the ready oxidation of iron(II). Oxyhemoglobin, therefore, should be quite resistant to oxidation. Any ligand, such as CO, F^-, CN^-, or even alcohols [assuming behavior similar to that of iron(III) (*3*)] which can displace the water of solvation of iron(II) should impair oxygen transport by hemoglobin and produce unfortunate physiological effects. In the instance of free heme, on the other hand, with presumably two waters of solvation, the situation is less critical, and even when one of the water molecules is replaced by oxygen or some ligand the remaining water will still provide a path for electron transfer.

Oxygenated heme ("oxyheme"), if formed, would be unstable in aqueous solution and would be oxidized immediately to the ferric state, just as certain synthetic, reversible oxygen-addition complexes of iron(II) that have been reported (*11*) are unstable in the presence of water.

$Mo(CN)_8^{-3}$ and $IrCl_6^{-2}$ oxidize hemoglobin and its derivatives (*12*). Possibly the species $Mo(H_2O)(CN)_7^{-2}$ and $Ir(H_2O)Cl_5^-$, carrying their own water bridges, are responsible for the oxidation. Dissociation of the derivative, as in the case of the oxidation of carbonmonoxyhemoglobin by $Fe(CN)_6^{-3}$, or displacement of the ligand of iron(II) by the anionic oxidant, may be a preliminary step. It is significant to notice that cationic oxidizing agents, such as $Fe(phenanthroline)_3^{+3}$ and $Ru(dipyridyl)_3^{+3}$, of equal or even greater oxidizing power, are ineffective (*12*), although size rather than coulombic repulsion may be critical in these cases.

Consideration of the role of water, together with specific protein influences, may well provide an explanation for the behavior of hemoglobin and related compounds without recourse to speculation concerning the microscopic dielectric constant at reaction sites.

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References

1. F. Haurowitz, "The bond between haem and globin," in *Haemoglobin*, F. J. W. Roughton and J. C. Kendrew, Eds. (Butterworths, London, 1949).
2. J. H. Wang, A. Nakahara, E. B. Fleischer, *J. Am. Chem. Soc.* 80, 1109 (1958); J. H. Wang, paper presented at the 134th meeting of the American Chemical Soc., Chicago, Ill., Sept. 1958.
3. R. A. Horne, *J. Phys. Chem.* 62, 509 (1958).
4. J. Silverman and R. W. Dodson, *ibid.* 56, 846 (1952).
5. R. A. Horne, thesis, Columbia Univ., 1955.
6. J. Hudis and A. C. Wahl, *J. Am. Chem. Soc.* 75, 4153 (1953).
7. G. S. Lawrence, *Trans. Faraday Soc.* 53, 1326 (1957).
8. J. Hudis and R. W. Dodson, *J. Am. Chem. Soc.* 78, 911 (1956).
9. W. L. Reynolds and R. W. Lumry, *J. Chem. Phys.* 23, 2460 (1955).
10. R. Lemberg and J. W. Legge, *Hematin Compounds and Bile Pigments* (Interscience, New York, 1949).
11. A. H. Corwin and Z. Reyes, *J. Am. Chem. Soc.* 78, 2437 (1956).
12. P. George and D. H. Irvine, *J. Chem. Soc.* 1954, 587 (1954).

9 February 1959

Inheritance of Diego Blood Group in Mexican Indians

Abstract. Diego blood factor is characteristic of Mongoloid populations. A study of 152 samples from Mexican Indians (Tlaxcaltecans) revealed this factor in 20.39 percent of the cases. Analysis of 30 Indian matings with 62 children support the hypothesis that the Diego antigen is transmitted through a gene capable of expressing itself in a single or double dose.

The studies of the Diego blood factor (Di^a) were begun in 1954, when Levine, Koch, McGee, and Hill (*1*) demonstrated its presence in the serum of a Venezuelan mother whose baby had hemolytic disease. This antibody, besides having pathological importance, has proved to be of considerable anthropological interest, for it exists only exceptionally in the blood of the Caucasoid (*2*) and has not been found in Negroes (*3*), in Australian aborigines, or in Polynesians (*4*), while it has been detected in Mongoloid bloods in percentages ranging from 5 (in Chinese from Canton) (*5*) to 45.8 (in Kainganges Indians, in Brazil). According to our studies of a sample of 152 bloods taken from not-closely-related Tlaxcaltecan Indians with some slight Spanish mix-

Table 1. Inheritance of Diego blood factor (Exp., expected; Obs., observed).

Matings (Obs.)	Children			
	Di(a+)		Di(a–)	
	Exp.	Obs.	Exp.	Obs.
D × D (0)	0	0	0	0
D × d (11)	11.1	8	9.9	13
d × d (19)	0	0	41	41

ture, the character Di^a (+) is present in 20.39 percent.

Inheritance of the Di^a (+) factor was studied in four families by Layrisse, Arenas, and Dominguez Sisco in 1955 (*6*), and later, in 1957, Lewis, Kaita, and Chown (*7*) gave a large pedigree formed by 50 Japanese families. The present study deals with the testing with anti-Di^a serum of 30 Indian matings with 62 children. The results are shown in Table 1 (*8*).

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References and Notes

1. P. Levine, E. Koch, R. McGee, G. Hill, *Am. J. Clin. Pathol.* 24, 292 (1954).
2. P. Levine, E. A. Robinson, M. Layrisse, T. Arens, *Nature* 177, 40 (1956).
3. M. Layrisse and T. Arends, *ibid.* 179, 478 (1957).
4. R. T. Simmons, *ibid.* 179, 970 (1957).
5. M. Layrisse and T. Arends, *ibid.* 177, 1083 (1956).
6. M. Layrisse, T. Arends, R. Dominguez Sisco, *Acta Med. Venezolana* 3, 132 (1955).
7. M. Lewis, H. Kaita, B. Chown, *Am. J. Human Genet.* 7, 724 (1957).
8. Anti-Diego serum was generously donated by M. Layrisse. We are indebted to R. R. Race for revising this manuscript. This work was supported by a grant from David Matson.

22 January 1959

Experimental Infestation of Peromyscus leucopus with Larvae of Cuterebra angustifrons

Abstract. Four newly hatched larvae of the warble fly, *Cuterebra angustifrons*, were successfully introduced into the mouse host, *Peromyscus leucopus*, by application to the belly skin, the mouth, and the nose. Regardless of the site of entry, each larva migrated to the inguinal region of the host and completed its development normally.

Cuterebrid flies are widely distributed in North and South America. Their larvae are found encapsulated in the subcutaneous tissues of many rodents (chipmunks, deer mice, pack rats, and so on), rabbits, and occasionally dogs, cats, and other mammals. Larvae of two species of the genus *Cuterebra* (*C. angustifrons* and *C. grisea*) have been found infesting the common deer mouse of wood lots in southern Ontario, *Peromyscus leucopus noveboracensis* (*1, 2*). Maturing larvae are usually observed beneath the skin of the inguinal region but have been seen elsewhere on the body of the hosts. After gaining entry to the host, larvae wander beneath the skin for the first 7 to 8 days and are not visible externally during this period. They then make a small hole in the skin, to which they apply their posterior ends for respiration and excretion. At this time they are in the second instar (recognizable by the characteristic stigmal plate pattern) and may remain in this stage for up to 8 days. After molting to the third instar (recognizable by the change in the stigmal plate pattern) they begin the final phase of larval development, which lasts an average of 12 to 13 days but may vary from 8 to 17 days. When mature, the third instar larva drops from its host, burrows into the ground, and pupates. The time for total development of the larva in its host varies from 19 to 44 days, but probably averages between 25 and 30 days (*2*).

Numerous adult flies have been reared over two winters, but attempts to mate flies in the laboratory have been unsuccessful to date (*2, 3*). Adult flies were not seen in four summers of observation in wood lots from which infested deer mice were trapped. No eggs were seen on the hair or skin of some 1000 deer mice, chipmunks, and other small mammals live-trapped during four summers (*3*). Beamer *et al.* (*4*) found eggs of *Cuterebra beameri* affixed to brush in and around the entrances to burrows of the pack-rat host. Presumably, eggs of cuterebrids are not laid on the bodies of their mammalian hosts. It has been demonstrated that larvae of *C. tenebrosa* may enter the host by mouth (*5*) or by penetration through the skin (*6*); those of *C. angustifrons*, by nose (*7*).

We were fortunate in capturing a female *C. angustifrons* in a cabin at Sparrow Lake, Ontario, 5 Sept. 1958. Since obtaining fertile females for experimental infestations is difficult, in that these flies have not as yet been mated in captivity and fertile females are only rarely taken in the field, we think the following observations worth reporting.

The fly began to oviposit within a few minutes on moistened tissue paper in a glass tumbler and laid a total of 86 eggs within 24 hours. She died 24 hours later. The eggs were placed in a humidor above a saturated solution of sodium chloride (relative humidity approximately 83 percent). Several eggs were examined on the sixth and seventh days after oviposition. Fully formed larvae were found in five eggs; three others showed no development and may have been infertile. One of the larvae, when exposed by removal of the operculum, exhibited feeble movements but died without escaping from the egg.

On the 12th day after oviposition, a larva was seen to have hatched. A closer check revealed three more larvae, one of which was observed in the act of pushing off the operculum and escaping from the egg. Two other larvae had hatched but died before they were found. An examination of the remaining eggs showed that many contained fully formed embryos, but all of these appeared to be dead.

Laboratory-raised *Peromyscus* juveniles were used as hosts for available larvae. Mouse No. 441-48 was prepared by clipping its belly hair and lightly anesthetizing it with ether. A larva was transferred on the moistened tip of a dissecting needle and placed on the dry clipped area. It seemed to be unable to navigate and struggled helplessly among the short clipped hairs. Moistening the hair with water seemed to help, but it still made no attempt to penetrate the skin. A slight abrasion was made in the belly skin. The larva was placed close to but not in the wound. However, fluid from the wound bathed it and it began to burrow into the unbroken skin. When about half buried it remained inactive for a minute or more, and during this time the mouse moved out of the field of the dissecting microscope. When it was again brought into view, the larva was no longer seen. It was not certain at this time whether the larva had been dislodged or had gained entry to the host.

A second larva was placed between the nostrils of mouse No. 431-58. It appeared to be quite active on the moist tip of the nose and moved quickly toward one of the nostrils. The mouse moved out of the field of observation, and the larva had disappeared from view when observations were resumed.

The third larva was placed in the mouth against the lip of mouse No. 432-58. It seemed to be stimulated by the moist environment and was observed to move out of sight along the side of the tongue towards the back of the throat.

With the last larva available, a second attempt at nasal transplant was made. The larva was seen to disappear actively down the nasal passage, but the mouse failed to revive from the anesthetic, even though oxygen was applied. About 20 minutes after the attempt, the dead mouse was necropsied, and the larva was found embedded in the tissue of the nasal septum about ¼ in. from the naris. It was motionless and appeared to have a gas bubble in its alimentary tract. After being removed from the nasal tissues, the larva revived somewhat and was transferred to the tongue of mouse No. 435-58. In this case no anesthetic was used, and the mouse appeared to swallow the slowly moving larva.

Larvae from the first three transfers reappeared in the inguinal region 8 days after entry via skin, nostril, and mouth; in the fourth instance, 12 days elapsed before the larva reappeared. In the first three cases, the molt from second to third instar was observed on the 11th day after experimental infestation; in the fourth case, the molt occurred on the 15th day. There was no significant difference in the length of the third instar —13 days for the first three larvae, 14 days for the fourth. Three of the four larvae dropped on the 24th day, the fourth on the 29th day, after infestation. Three of the four successfully pupated,

but all were dead at the time of this writing. The extended period of early development of the fourth larva in contrast to that of the others may have resulted from adverse effects of extra handling, ether anesthesia, application of oxygen, or a combination of these factors.

It is possible that direct application of moisture is necessary for successful hatching of cuterebrid larvae from the egg, as indicated by the erratic hatching observed in this work. In nature, eggs laid on vegetation would be subject to the influence of dew. Further, they may be ingested by mice in connection with lapping of dew or ingestion of vegetation and may hatch in the mouth or esophagus. On the other hand, larvae may be stimulated to hatch by the action of the tongue alone or through application of moisture by the tongue. Finally, Gregson (*8*) has suggested that the mechanical stimulus of a host brushing past the eggs may be a factor in hatching.

It is interesting to note that all four experimentally introduced larvae reappeared and settled beneath the skin of the inguinal region for development, two on the left side, two on the right. In nature, at least 80 percent of the larvae are seen in the inguinal region, equally divided between the right and left sides. Possibly significant physiological and biochemical differences in the environment beneath the skin of various regions of the body may be factors in this striking regional preference, causing some larvae to reappear beneath the skin close to their point of entrance (perhaps as a result of it), others to migrate a short distance, and most to reappear in the groin. Perhaps many larvae, no matter how they gain entrance to the host, are influenced in their early movements beneath the skin by sensory cues derived from the movements of the body muscles of the host and, in this way, are guided to the inguinal region.

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References and Notes

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2. E. I. Sillman, *Ann. Rept. Entomol. Soc. Ontario, 86th Rept.* (1956), pp. 89–96; *Ann. Rept. Entomol. Soc. Ontario, 87th Rept.* (1957), pp. 28–40.
3. ———, unpublished data.
4. R. H. Beamer, L. R. Penner, C. W. Hibbard, *J. Kansas Entomol. Soc.* 16, 47 (1943).
5. R. R. Parker and R. W. Wells, *J. Parasitol.* 5, 100 (1919).
6. T. K. Moielliet, *Proc. Entomol. Soc. Brit. Columbia* 46, 1 (1950).
7. L. R. Penner and F. P. Pocius, *J. Parasitol.* 42, 42 (1956).
8. J. D. Gregson, *Proc. Entomol. Soc. Brit. Columbia* 46, 3 (1950).

24 February 1959

Fate of Frog Embryos Implanted into Forelimbs of Adults

Abstract. No teratoma formation and very little growth and differentiation followed implantation of late gastrula-stage frog embryos into forelimbs of adults. This is attributed to poor blood supply and rigid walls of muscle and bone surrounding the implants. The fate of embryos in nonamputated limbs is compared with that of regeneration-promoting implants in amputated limbs.

Several investigators reported formation of tumors following implantation of embryonic material into adult amphibians. Allison (*1*) observed uncoordinated masses of growing tissue which developed from embryonic transplants to the coelom or orbit of larvae or adults, with metastases and infiltrating growth in larval hosts but none in adults. Fankhauser and Stonesifer (*2*) produced teratomas by implanting newt embryos under the skin of the lower jaws of adults. It has been reported that embryonic implants into adult limbs are capable of promoting regeneration of these limbs following their amputation (*3*). The present study deals with the fate of embryos implanted into adult limbs which were not subsequently amputated.

Ten adult *Rana pipiens* served as hosts. Late gastrula-stage *R. clamitans* embryos served as donors. The adults were anesthetized with ether, and longitudinal incisions on the dorsal surface of the left forelimbs were made. The radioulnas and associated arteries and nerves were exposed. Muscles and skin were retracted with small hooks, and donor embryos were placed in these artificially created pockets. The embryos had been denuded of their jelly capsules and vitelline membranes prior to amputation. The wounds were closed with silk. Aseptic technique was used throughout. The wounds healed within 2 or 3 days without complications. The stitches were removed as soon as primary healing took place. The animals were killed at various intervals for histological examination, the last one 3 months postoperatively.

No inflammatory reaction was observed around the implants. The operative wounds healed by primary intention with a minimal amount of scarring. The implanted embryos were clearly distinct in all specimens. Embryonic differentiation and resorption were almost entirely absent up to 3 months following implantation. The only attempts at differentiation noted were formation of a cavity lined by cells, resembling ependymal cells, and a few muscle fibers within the implants. No differentiated nervous elements, notochord, digestive tract, or cartilage were present in any sections. The epidermal covering was lost soon after transplantation. The embryos did not increase in size. The implants were composed mainly of numerous strongly basophilic yolk granules and large round cells with vesicular nuclei. There was no clean and obvious line of demarcation around the implants, and it was impossible to ascertain which cells arose from the implants and which from the host. There was no foreign-body reaction in the host. No invasive growth was observed in any of the implants.

The fate of embryo and larval implants was considerably different in amputated limbs (*3*). Implants remained viable for a prolonged length of time, contributed cells to the regenerating limb bud, and finally blended with the host tissues. The blood supply to the regenerating stump was very good. No neoplastic change was observed in any of these implants.

Very little differentiation and no invasive growth or teratoma formation were observed in the embryos implanted into adult frog limbs. This could be explained by the unusual site of implantation. The embryos were surrounded by rigid walls composed of muscle and bone, which gave them little or no opportunity to expand. In contrast to the situation with amputated limbs, the blood supply to the areas of implantation was exceedingly poor. This of itself could account for the retardation in growth and development of the implants. It is suggested that the embryos received enough oxygen and nutrient materials by diffusion to keep them alive but that the amounts were grossly inadequate for further growth and differentiation.

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References

1. J. E. Allison, *Anat. Record* 122, 561 (1955).
2. G. Fankhauser and G. L. Stonesifer, Jr., *J. Expll. Zool.* 132, 85 (1956).
3. T. Malinin and J. D. Deck, *ibid.*, in press.

25 May 1959

Letters

(*Continued from page 128*)

When Gates wrote this paragraph he was not writing as a scientist, for he is demonstrably wrong about ascertainable facts, nor was your journal in printing it contributing to the advancement of science by the pursuit of truth.

The Republic of Ireland (*Eire* is Gaelic for the whole country) is not overpopulated in the normal meaning of the word. Its population density (41 per square kilometer) is one-eighth that of the Netherlands, one-third that of Switzerland, and less than half that of Denmark. It is about equal to that of overpopulated (?) Indiana or Michigan.

If the Republic of Ireland, with a per capita net income of 410 U.S. dollars per annum, is "tragically poor," how must we designate Italy ($310), Portugal ($200), India ($60)? "Hypertragically" might be employed. And what of the Netherlands, of which your contributor rightly speaks well? Is it "hypotragically poor," with an income but some 20 percent higher than that of Ireland?

Again, our figure for motor vehicles per thousand of the population (85) is not greatly below that of Great Britain (110), and our per capita annual consumption of energy (1.8 tons of coal equivalent) is 80 percent that of the Netherlands or Denmark. We have 50,000 television sets in the area (population 1 million) in which reception is at present available.

Had Gates visited Ireland (I presume he must not have done so) he might, I admit, have concluded that we lived with the belief that, having only one life, some part of it should be devoted to play. We have, possibly, too many race meetings and golf courses. But he would not have seen much evidence of "tragic poverty" among the best-fed people in the world (3550 calories per head per day, as compared with 3220 in the United States). We rather like our well-fed poverty; our suicide rate is among the lowest in the world (this includes the Western Hemisphere). "Poor"—perhaps more than slightly; "tragically poor"—to princes and millionaires only.

I now turn to Gates' remark that we are "totally lacking in organization for research." He should take a lesson from the politicians and beware of categorical statements unless he knows they are true. They are so easy to refute, while the difficulty of contradiction increases with the degree of qualification. Perhaps I had better list our more important organizations, though to mention one would be sufficient to knock out the "totally."

We have two universities, the National University of Ireland, with constituent colleges in Dublin, Cork, and Galway, and Dublin University, which has Trinity College. The degree examinations, graduate and research, are conducted in collaboration with external examiners from other (mainly British) universities, and the degrees themselves are recognized by the British as equivalent to their own degrees. Our graduates are recruited by foreign firms on the same conditions as British graduates.

Research is actively pursued in our university departments of science. It is supported by the Government and the local authorities, and by the Medical Research Council of Ireland (that of Britain also makes grants), by the Rockefeller Foundation, by United States agencies—for example, the European Research Office of the U.S. Army—and by Irish and foreign industry. Some of our professors have world-wide reputations in their fields of work; E. J. Conway, head of our department of biochemistry, is outstandingly distinguished. They find demand for their services as visiting lecturers at universities and before learned societies outside the country. About 150 scientific papers emanate each year from the Republic.

A number of Irish students go to the United States to hold postdoctoral fellowships. We do not hear complaints about their lack of research training; indeed, they seem to do quite well.

Many scientific organizations have thought it worth while to hold international gatherings in Dublin. The universities were hosts to the 1957 annual meeting of the British Association for the Advancement of Science. The International Astronomical Union met in Dublin in 1955; in the same year an International Symposium on Plant Products was organized in this college. The British Faraday Society assembled here for a discussion on "Ions of the Transition Elements" in September 1958. This autumn there is to be an International Conference on Humic Acids. I could readily extend this list.

Our scientific roots run deep; the Chemical Laboratory at Trinity College, Dublin, was established in 1711 and our chair of chemistry in this college, in 1796. The latter is one of the oldest in Great Britain and Ireland formed outside a medical school.

The science library facilities in Dublin are of a high order. Trinity College Library was established in 1591. It receives by law a copy of every book published in Ireland and in the United Kingdom. The library of the Royal Dublin Society dates back to 1731, and that of the Royal Irish Academy to 1786. Our own College Science Library was started in 1845. There are few important scientific journals of which complete runs are not available here, bought as issued and not later as photocopies or in sets.

The National Observatory at Dunsink, near Dublin, was founded in 1785.

It has had distinguished directors, among them Sir William Hamilton (1805–65), whose work was of great importance in the development of quantum mechanics.

The Dublin Institute for Advanced Studies, which trains postgraduate students, was set up in 1940. It contains departments of theoretical and cosmic physics and has had rather distinguished people on its staff—Ernest Schrödinger and Walter Heitler, for example. We get numerous applications from abroad for scholarships to be held in the institute. The Dublin climate can scarcely be the attraction.

The Royal Dublin Society was organized in 1731 to promote the study of agriculture and science in Ireland. Its School of Applied Science (1796) was one of the earliest developed in the then United Kingdom. This School eventually became the Royal College of Science for Ireland, the courses of which were modeled on those of the Imperial College of Science in London. The Royal College was amalgamated with University College in 1926.

The society has published for many years its *Scientific Proceedings of the Royal Dublin Society* and has journal exchanges with institutions all over the world. It gives grants to promote research and each year brings two or three distinguished scientists from England to lecture here.

The Royal Irish Academy was chartered in 1786. Its functions here parallel those of the Royal Society in London. It publishes scientific and literary proceedings and has exchanges with academies in many countries. It is responsible for the Irish National Committees which are linked with the International Scientific Unions. For example, it organizes the work of the Irish National Committee on Chemistry, which is affiliated with the International Union of Pure and Applied Chemistry. The academy has, for one of its duties, the screening of applications for awards that are offered by the U.S. National Academy of Sciences.

The Medical Research Council controls research into medical problems of importance to Ireland. The work of Vincent Barry and his team on the chemotherapy of tuberculosis is internationally distinguished. Barry has lectured in Britain, Europe, India, and the United States; he has, I know, spoken in Denver. His work, while mainly financed by the Irish Government through the Medical Research Council, has also been supported by a large European firm and by the Lasdon Foundation of New York. An International Colloquium on the Chemotherapy of Tuberculosis was held in Dublin in 1951. It was attended by distinguished workers from many countries.

The Irish Department of Agriculture has subsidized research in a number of branches of agriculture for many years.

Its research journal is well known—even though Gates never heard of it. Recently, many of these functions have been taken over by a new Institute of Agricultural Research, founded with the aid of grants from the United States (Counterpart Fund). The Soil Research Centre at Johnstown Castle, Wexford, which has been working for a number of years, has a high reputation. The Agricultural College attached to University College, Dublin, was established in 1838 and is one of the oldest in these islands.

The Institute for Industrial Research was founded in 1946. It developed from an Industrial Research Council which goes back to 1934. The institute works on problems of interest to Irish industry. Its testing facilities are being extended with the aid of grants from the Counterpart Fund. In addition, industrial research is carried out by the bigger agencies, such as Messrs. Guinness, the Irish Peat Board, and the Irish Sugar Company. A very famous statistician (who wrote under the pseudonym of "Student") was attached to the scientific staff of Messrs. Guinness.

There is quite a lot of "cross fertilization" from abroad. I have referred to the work of the Royal Dublin Society in bringing over British lecturers. This is but a small part of what is done in the way of arranging lectures by distinguished foreigners.

The Chemical Society (of London), the Royal Institute of Chemistry and the (British) Society of Chemical Industry have flourishing local sections in Dublin. They, with the Institute of Chemistry of Ireland, have a Conjoint Chemical Council which arranges lectures in Dublin. The current program shows 11 lectures by foreigners.

In addition, the universities arrange many addresses by professors from abroad. In this department we had ten last session. We also had R. Bognár of Debrecen, Hungary, as visiting professor for a term.

I hope I have cited facts to show that Ireland is not "overpopulated," is not "tragically poor," is not "totally lacking in organization for research" and is not without "cross fertilization" from abroad.

Apart from putting Gates's statement in the proper perspective, this letter may provide new facts for your readers. I was surprised, when in the United States, to find that some of your countrymen seemed to think I should express amazement at the sight of electric light.

In taking issue with Gates I do not, of course, claim that we are underpopulated like your Western states, or that we are not poor by United States standards, or that we are not underorganized in research. I merely state that we are not as totally backward as Gates implies.

T. S. WHEELER

Department of Chemistry,
University College, Dublin, Ireland

I am pleased to be corrected for my ill-chosen words concerning the Republic of Ireland, and I hope that these were not taken as any lack of appreciation for the wonderful hospitality extended to me during my visit to that beautiful, romantic country. Apparently, the economy of Ireland is stronger than the impression of it a visitor receives; however, the fact still remains that due to economic necessity many people (especially students) find it necessary to find employment elsewhere. Many countries or states throughout the world can list numerous universities, institutions, societies, libraries, and traditions which, by themselves, do not imply good organization for scientific research. However, their very existence should provide the basic environment from which a broad spectrum of knowledge, stemming from research, should flow.

In my article it was impossible for me to describe in detail the scientific activity of every European country, and for this reason I wish to thank Hearne and Wheeler for their informative letters.

DAVID M. GATES
Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado

Subcool and Supercool

The recent exchange of views [*Science* 129, 1296 (1959)] between meteorologists Braham and Appleman relative to *super-* and *subcooling* intrigues me. It might be of interest that chemical process engineers, who have intimate contact with related physical phenomena, have no problem with these words. They are not used interchangeably. Each has a distinct and separate meaning.

The engineer's definition of *supercool* coincides with that of Webster: "to cool below the freezing point without solidification." For example: Liquid glycerine can be supercooled many degrees without crystal formation.

Subcool in the engineer's parlance is defined as "to cool a liquid below the equilibrium temperature at which condensation takes place." For example: The alcohol condenser in this process is designed for 20°F subcooling. In actual practice, condenser calculations are made with separate consideration of heat transfer surface "for condensation" and "for subcooling."

Since it appears that meteorologists have not made up their minds concerning usage of these two words, may I have the pleasure of inviting them to join with the engineers? Consistency of terms throughout the scientific fraternity is worthy of attainment.

R. E. MORRISON
177 White Plains Road, Tarrytown, New York

Meetings

Friends of the Pleistocene

On the evening of 8 May 1959, the Midwestern Friends of the Pleistocene assembled at Hotel Eau Claire, Eau Claire, Wis., for their tenth annual field conference. Under the leadership of Robert F. Black (University of Wisconsin), about 90 participants from the Midwest, Washington, D.C., and Denver, Colo., spent a day and a half examining the glacial geology of west-central Wisconsin. On the first day the group traveled in private cars from the prominent St. Croix moraine of Cary age, near Hudson, southeastward across pre-Cary deposits to the vicinity of the Chippewa River. The next day, glacial deposits of pre-Cary age were examined in the vicinity of Eau Claire.

Research that led to the field conference was started in the fall of 1956, with the financial assistance of the Wisconsin Alumni Research Foundation. Studies were conducted during the school year by Robert F. Black, assisted by L. A. Bayrock, Thomas E. Berg, and Elizabeth H. Kissling. Some data were gathered under the auspices of the Wisconsin State Highway Commission.

It is still too soon to draw definite conclusions from many of the various studies being carried on. Many tentative conclusions were presented for the benefit of participants of the conference. Most important is the conclusion that no surficial glacial deposits in west-central Wisconsin are older than early Wisconsin, the previous correlations of deposits in concentric belts with Illinoian, Kansan, and Nebraskan notwithstanding.

In northwest St. Croix County the Cary front in places is a pronounced terminal moraine of clay-silt-sand till; generally, only thin ice-stagnation features of relatively clean, gravelly sand may be found for several miles beyond what normally would be considered the main terminal moraine. The small size of the stagnation features, the paucity of outwash deposits, the slight reworking of older outwash deposits, the obvious inability of the ice to cover low uplands and to erode, and the obvious topographic control and gravity flow of ice in diverse directions within lowlands suggest a warm and very thin advance of ice at a late stage of the Cary. Where poorly sorted till is found back of the outermost limits of the Cary advance, leaching to depths of many feet, considerable alteration of minerals in the finer fraction, and oxidation through tens of feet of material suggest that older, weathered till constitutes the bulk of the material transported and deposited by the Cary ice. The Cary advance blocked established drainage lines, of which few became reestablished; drainage is poorly integrated—undrained depressions are characteristic. Primary depositional features are essentially unmodified. Ice flow was southeastward near Hudson in the St. Croix lobe and southwestward near Chippewa Falls in the Chippewa lobe; ice from both lobes came through the Lake Superior lowland. The Kinnickinnic, Rush, Red Cedar, and Chippewa river valleys carried outwash from the Cary ice, the last two being by far the most important. An extensive system of terraces in the Chippewa, St. Croix, and Mississippi river valleys and their immediate tributaries has not been studied.

Deposits left by an advance slightly older than the Cary and tentatively assigned to Tazewell age are identified in west-central St. Croix County, north of highway 12 and outside the Cary front. For lack of time they were not examined during the field conference.

Deposits left by an older advance are of several lithologies and textures, the main types being: (i) a basal dark-gray clayey till restricted to areas underlain with dolomite; (ii) a reddish-brown sandy till in areas underlain with sandstone and generally on top of, but also mixed with, the dark-gray clayey till in areas underlain with dolomite; and (iii) stratified glacial-fluvial deposits of many kinds. All gradations of these units may be found. Patches of unleached till are not common. Leaching penetrates from a few inches to more than 15 feet, depending on the original carbonate content and texture. Most till accumulations are only a few feet thick, but maximum thickness of drift exceeds 100 feet, as at Woodville. Till is absent over large parts of the area, and glacial deposits are limited commonly to a few scattered erratics or to a few inches of colluviated materials in part derived from glacial drift.

Kames are a conspicuous feature of the deposits and are found almost everywhere northwest of the Chippewa River. Moulin kames are most abundant; kame terraces and irregular kames also attest to ice stagnation. The wide range of lithology and texture of kame materials in adjacent deposits demonstrates the complexity of the situation—dolomite gravels may be adjacent to noncalcareous iron-stained gravels or to partly calcareous gravels with thick clay-ironstone concretionary shells. Cemented and uncemented, unoxidized and oxidized, fresh and disintegrated materials may lie side by side in perplexing array. However, the degree of surface modification of the kames is similar throughout.

The dark-gray clayey till seems to be typical lodgment till; the sandy till is partly ablation debris. Patches of thick drift cannot be aligned into simple moraines or ice fronts, nor can the kames or concentrations of large erratics distributed so widely in the area. The irregularity of drift deposition seems to reflect merely the fact that the drift was concentrated irregularly in the ice when it stagnated. Movement of early Wisconsin ice throughout the area from Eau Claire westward to Hudson is believed to have been from the north to the northwest, and distinct lobes, such as occurred in the late Wisconsin advances, did not exist.

Considerable postglacial erosion of bedrock, particularly sandstone, has occurred. Solifluction lobes, involutions, terracettes, stone stripes, ice-wedge casts, mass-wasted scallops, and sapped cliffs point to former cold climates and to dominance of gravity movements and frost processes over stream action at some time after deglaciation. Geomorphic analysis of the older landscape reveals no areas of distinctly different ages. The incomplete weathering and relatively minor dissection of thick deposits indicate an early Wisconsin age; this has been confirmed with two carbon-14 dates which give approximately 30,000 years for the advance of early Wisconsin ice across a residual soil with much chert and a forest cover on dolomite. [Sample W-747 (U.S. Geological Survey) is spruce, dated at 29,000 ± 1,000 years before the present, from dark-gray clayey till at a depth of 14 feet about 3 miles southwest of Hammond, in the NW¼, SW¼, Sec. 6, T 28N, R 17W; sample Y-572 (Lamont Laboratory) is spruce, dated at 30,650 ± 1,640 years before the present, from dark-gray clayey till at a depth of 50 feet in the Chicago, St. Paul, Minneapolis, and Omaha railroad cut in Woodville]. The similarity of the upper parts of thick drift, with thin drift occurring patchily over the area, indicates that no great difference in age or source can exist.

Lapping of the early Wisconsin ice onto the "driftless area" brought the clean upper portions of the ice sheet onto the higher ridges so that little erratic material was available for deposition. Hence, the limits of the early Wisconsin advance must be determined by vague criteria such as thickness of residual materials, loess accumulations, drainage changes, and erosional features. None is particularly diagnostic. Early Wisconsin ice is believed to have extended farther into the "driftless area" than is shown on most published maps, but positive proof is lacking.

The presence of materials of diverse lithology and great range of alteration in adjacent deposits suggests that the early Wisconsin ice reworked older glacial deposits. Glacial deposits buried tens of feet below the surface and beneath a buried soil that is older than 45,000 years were found by Francis Hole (written communication, 13 Sept.

1958) in Wood County. It is likely that west-central Wisconsin also was glaciated sometime prior to the advance dated about 30,000 years ago, but it is not known whether this was pre- or post-Sangamon.

ROBERT F. BLACK
Department of Geology,
University of Wisconsin, Madison

Forthcoming Events

August

16–19. Botanical Nomenclature, discussions (Intern. Bureau for Plant Taxonomy and Nomenclature), Montreal, Canada. (J. Rousseau, Natl. Museum, Ottawa, Canada.)

16–21. American Pharmaceutical Assoc., Cincinnati, Ohio. (R. P. Fischelis, APA, 2215 Constitution Ave., NW, Washington 7.)

17. Ultrasonics, natl. symp., San Francisco, Calif. (L. G. Cumming, Inst. of Radio Engineers, 1 E. 79 St., New York 21.)

17–21. Pacific Southwest Assoc. of Chemistry Teachers, Pacific Grove, Calif. (W. A. Craig, 416 N. Citrus Ave., Los Angeles 36, Calif.)

17–22. Logopedics and Phoniatrics, 11th intern. cong., London, England. (Miss P. Carter, 46 Canonbury Square, London N.1, England.)

19–26. Refrigeration, 10th intern. cong., Copenhagen, Denmark. (M. Kondrup, Danish Natl. Committee, Intern. Congress of Refrigeration, P.O. Box 57, Roskilde, Denmark.)

19–29. Botanical Cong., 9th intern., Montreal, Canada. (C. Frankton, Secretary-General, 9th Intern. Botanical Cong., Science Service Bldg., Ottawa, Ontario, Canada.)

19–29. International Assoc. of Wood Anatomists, Montreal, Canada. (IAWA, Laboratorium für Holzforschung E.T.H. Universitatstrasse 2, Zurich, Switzerland.)

19–29. Mycological Soc. of America, Montreal, Canada. (E. S. Beneke, Dept. of Botany and Plant Pathology, Michigan State Univ., E. Lansing.)

19–29. Phycological Soc. of America. Montreal, Canada. (W. A. Daily, Dept. of Botany, Butler Univ., Indianapolis 7, Ind.)

20–22. Rocky Mountain Radiological Soc., Denver, Colo. (J. H. Freed, 4200 E. Ninth Ave., Denver 20.)

20–25. Chemical Thermodynamics, symp., Wattens, Austria. (F. Vorländer, Deutsche Bunsen-Gesellschaft, Carl-Bosh-Haus, Varrentrappstrasse, 40–42, Frankfort a.M., Germany.)

20–27. Therapeutics, symp., Gardone, Italy. (R. Morf, c/o Sandoz S.A., Basel 13, Switzerland.)

20–2. Limnological Cong., 14th intern., Vienna and Salzburg, Austria. (Secretary, 14th Intern. Limnological Congress, Biologische Station, Lunz am See, Austria.)

23–26. American Farm Economic Assoc., Ithaca, N.Y. (C. D. Kearl, Dept. of Agricultural Economics, Warren Hall, Cornell Univ., Ithaca.)

23–26. Electromation, 6th electrical conf. of petroleum industry, Long Beach,

Calif. (AIEE, 33 W. 39 St., New York, N.Y.)

23–27. Veterinary Medicine, 3rd Pan-American Cong., Kansas City, Mo. (B. D. Blood, Pan-American Congresses of Veterinary Medicine, P.O. Box 99, Azuk, Buenos Aires Province, Argentina.)

24–26. American Accounting Assoc., Boulder, Colo. (C. Cox, 437 Hagerty Hall, Ohio State Univ., Columbus 10.)

24–26. Anti-Submarine Warfare (classified), symp., San Diego, Calif. (R. R. Dexter, Inst. of the Aeronautical Sciences, 2 E. 64 St., New York 21.)

24–26. Dynamics of Conducting Fluids, symp. (American Rocket Soc., and Northwestern Univ.), Evanston, Ill. (J. J. Harford, ARS, 500 Fifth Ave., New York 36.)

24–27. American Hospital Assoc., New York, N.Y. (E. L. Crosby, 18 E. Division St., Chicago, Ill.)

24–28. Australian and New Zealand Assoc. for the Advancement of Science, 34th cong., Perth, Western Australia. (J. R. A. McMillan, Science House, 157 Gloucester St., Sydney, Australia.)

24–29. Infrared Spectroscopy Inst., 10th annual, Nashville, Tenn. (N. Fuson, Director, Infrared Spectroscopy, Fisk Univ., Nashville 8.)

24–29. International Assoc. for Hydraulic Research, cong., Montreal, Canada. (IAHR, c/o Laboratoire Hydraulique, Raam 61, Delft, Netherlands.)

24–29. Ionization Phenomena in Gases, 4th intern. conf., Upsala, Sweden. (A. Nilsson, Secretary-General, Inst. of Physics, Upsala, Sweden.)

24–29. Polarography, 2nd intern. cong., Cambridge, England. (Mrs. B. Lamb, Chemistry Lab., Evershed & Vignoles, Corner of Iveagh Ave., N. Circular Rd., London, N.W.10, England.)

24–30. Modern Systems for Detecting and Evaluating Optical Radiation (Intern. Optical Commission), symp., Stockholm, Sweden. (S. S. Ballard, Dept. of Physics, Univ. of Florida, Gainesville.)

25–27. Petroleum Industry Conf., AIEE, Long Beach, Calif. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

25–28. Alaskan Science Conf., Alaskan Div., AAAS, 10th, Juneau. (N. J. Wilimovsky, Bur. of Commercial Fisheries, Box 2021, Juneau.)

25–28. American Dietetic Assoc., 42nd annual, Los Angeles, Calif. (Miss R. M. Yakel, ADA, 620 N. Michigan Ave., Chicago 11, Ill.)

25–30. American Ornithologists' Union, Regina, Saskatchewan, Canada. (H. G. Deignan, Div. of Birds, U.S. National Museum, Washington 25.)

26–29. International Assoc. of Milk and Food Sanitarians, Glenwood Springs, Colo. (V. T. Foley, Health Dept., Kansas City, Mo.)

26–29. International Union of Pure and Applied Chemistry, 20th conf., Munich, Germany. (Div. of Chemistry and Chemical Technology, Natl. Research Council, Washington 25.)

27–29. American Assoc. of Clinical Chemists, 11th annual, Cleveland, Ohio. (A. Hainline, Jr., AACC, Cleveland Clinic Foundation, 2020 E. 93 St., Cleveland 6, Ohio.)

27–29. American Physical Soc., Hawaii. (K. K. Darrow, APS, Columbia Univ., New York 27.)

28–29. Weather Modification (with American Soc. of Civil Engineers), conf., Denver, Colo. (H. G. Houghton, AMS, Dept. of Meteorology, Massachusetts Inst. of Technology, Cambridge 39, Mass.)

28–30. American Folklore Soc., annual, Albany and Cooperstown, N.Y. (MacE. Leach, 110 Bennett Hall, Univ. of Pennsylvania, Philadelphia 4.)

28–31. Astronomical League, Denver, Colo. (R. Dakin, 720 Pittsford-Victor Rd., Pittsford, N.Y.)

28–4. International Union for Scientific Study of Population, cong., Vienna, Austria. (F. Lorimer, Dept. of Sociology, American Univ., Washington, D.C.)

30–3. American Inst. of Biological Sciences, annual, University Park, Pa. (H. T. Cox, AIBS, 2000 P St., NW, Washington 6.)

The following 17 meetings are being held in conjunction with the AIBS meeting at University Park, Pa.

American Microscopical Soc. (T. H. Cheng, Dept. of Zoology and Entomology, Pennsylvania State Univ., University Park.)

American Phytopathology Soc. (J. E. Livingston, Dept. of Botany and Plant

Pathology, Pennsylvania State Univ., University Park.)

American Soc. for Horticultural Science. (R. E. Larson, Dept. of Horticulture, Pennsylvania State Univ., University Park.)

American Soc. of Human Genetics. (C. C. Li, Graduate School of Public Health. Univ. of Pittsburgh, Pa.)

American Soc. of Limnology and Oceanography. (E. L. Cooper, Dept. of Zoology, Pennsylvania State Univ., University Park.)

American Soc. of Parasitologists. (T. H. Cheng, Dept. of Zoology and Entomology, Pennsylvania State Univ., University Park.)

American Soc. of Plant Physiologists. (A. A. Benson, Agriculture and Biological Chemistry, Pennsylvania State Univ., University Park.)

American Soc. of Zoologists. (A. Anthony, Dept. of Zoology, Pennsylvania State Univ., University Park.)

Biometric Soc. (ENAR). (Miss C. S. Weil, Mellon Inst., 4400 Fifth Ave., Pittsburgh, Pa.)

Ecological Soc. of America. (M. W. Schein, Dept. of Poultry Husbandry, Pennsylvania State Univ., University Park.)

Genetics Soc. of America. (J. E. Wright, Dept. of Genetics, Pennsylvania State Univ., University Park.)

National Assoc. of Biology Teachers. (H. S. Fowler, Science Education, Pennsylvania State Univ., University Park.)

Nature Conservancy. (W. Sharp, Pennsylvania Cooperative Wildlife Reserve, 206 Forestry Bldg., Pennsylvania State Univ., University Park.)

Society for Industrial Microbiology. (Miss M. B. O'Hara, Applied Sciences Labs., Inc., State College, Pa.; or A. Rose, 525 S. Gill St., State College.)

Society of Protozoologists. (H. Frings, Dept. of Zoology, Pennsylvania State Univ., University Park.)

Society for the Study of Development and Growth. (J. E. Livingston, Dept. of Botany and Plant Pathology, Pennsylvania State University, University Park.)

Tomato Genetics Cooperative. (B. L. Pollack, Dept. of Horticulture, Pennsylvania State Univ., University Park.)

30–4. American Cong. of Physical Medicine and Rehabilitation, Minneapolis, Minn. (Miss D. C. Augustin, 30 N. Michigan Ave., Chicago 2, Ill.)

30–4. Laurentian Hormone Conf., Mont Tremblant, Quebec, Canada. (G. Pincus, 222 Maple Ave., Shrewsbury, Mass.)

30–4. Medical Education, 2nd world conf., Chicago, Ill. (World Medical Assoc., 10 Columbus Circle, New York 19.)

30–5. World Federation for Mental Health, 12th annual, Barcelona, Spain. (Miss E. M. Thornton, Secretary-General, WFMH, 19, Manchester St., London W.1, England.)

30–6. History of Science, 9th intern. cong., Barcelona and Madrid, Spain. (J. Vernet, via Layetona 141, Barcelona.)

30–6. Residues on Crops and/or the Problem of Insect Resistance to Insecticides, symp., Munich, Germany. (R. Morf, Secretary-General, IUPAC, c/o Sandoz S. A., Basel, Switzerland.)

30–6. Thermodynamics and Experiperimental Thermochemistry, 17th intern. cong. (Internat. Union of Pure and Applied Chemistry), Munich, Germany. (Div. of Chemistry and Chemical Technology, Natl. Research Council, Washington 25.)

30–12. International Oceanographic Cong. (AAAS, UNESCO, ICSU), New York, N.Y. (Miss M. Sears, chairman, Woods Hole Oceanographic Institution, Woods Hole, Mass.)

31–2. Free Radical Stabilization, 4th intern. symp., Washington, D.C. (A. M. Bass, Natl. Bureau of Standards, Washington 25.)

31–2. Stratospheric Meteorology, conf., Minneapolis, Minn. (H. G. Houghton, AMS, Dept. of Meteorology, Massachusetts Inst. of Technology, Cambridge 39, Mass.)

31–3. Biological Photographic Assoc., Montreal, Canada. (Miss J. H. Waters, P.O. Box 1668, Grand Central Station, New York 17.)

31–3. Mathematical Assoc. of America, 40th summer meeting, Salt Lake City, Utah. (H. M. Gehman, MAA, Univ. of Buffalo, Buffalo 14, N.Y.)

31–4. Haematin Enzymes, symp. (by

invitation), Canberra, Australia. (A. H. Ennar, John Curtin School of Medical Research, Australian National Univ., Canberra.)

September

1–3. Association for Computing Machinery, natl., Cambridge, Mass. (J. Moshman, Council for Economic and Industry Research, Inc., 1200 Jefferson Davis Highway, Arlington 2, Va.)

1–6. College of American Pathologists, Chicago, Ill. (A. H. Dearing, Suite 2115 Prudential Plaza, Chicago 1.)

1–7. History and Philosophy of Science (General Assembly, History Div., Intern. Union of the History and Philosophy of Science), Barcelona, Spain. (R. Taton, IUHPS, 64, rue Gay-Lussac, Paris 5e, France.)

1–8. Acoustics, 3rd intern. cong., Stuttgart, Germany. (E. Zwicker, Breitscheidstrasse 3, Stuttgart N.)

1–7 Oct. International Civil Aviation Organization (Meteorological Div.), Montreal, Canada. (ICAO, Maison de l'Aviation Internationale, Montreal, Canada.)

2–4. Allergy, 4th European cong., London, England. (British Assoc. of Allergists, Wright-Fleming Inst., St. Mary's Hospital, London, W.2.)

2–4. Cryogenic Engineering Conf., Berkeley, Calif. (K. D. Timmerhaus, CEC, Chemical Engineering Dept., Univ. of Colorado, Boulder.)

2–4. Crystal Imperfections and the Chemical Reactivity of Solids (Faraday discussion), Kingston, Ontario, Canada. (Faraday Soc., 6 Gray's Inn Sq., London, W.C.1, England.)

2–5. American Mathematical Soc. and Mathematical Assoc. of America (joint summer), Salt Lake City, Utah. (E. Pitcher, AMS, Lehigh Univ., Bethlehem, Pa.)

2–8. Foundations of Mathematics: Infinitistic Methods, symp., Warsaw, Poland. (A. Mostowski, Dept. of Mathematics, Univ. of California, Berkeley 4.)

2–9. British Assoc. for the Advancement of Science, 121st annual, York, England. (Secretary, BAAS, 18 Adam St., Adelphi, London, W.C.2, England.)

3–6. American Sociological Soc., natl., Chicago, Ill. (D. Young, Russell Sage Foundation, New York 22.)

3–5. Nephrology, 1st intern. cong., Geneva, Switzerland, and Evian, France. (G. Richet, Hospital Necker, 149, rue de Sevres, Paris 7e, France.)

3–9. American Psychological Assoc., annual conv., Cincinnati, Ohio. (R. W. Russell, APA, 1333 16 St., NW, Washington 6.)

4–7. International Federation of Surveyors, annual (by invitation), Gracow, Australia. (IFS, 4, Kanaalweg, Delft, Netherlands.)

5–11. Application of Radiation Sources in Industry, intern. conf., Warsaw, Poland. (P. Fent, IAEA, Vienna, Austria.)

6–12. Standards on a Common Language for Machine Searching and Translation, intern. conf., Cleveland, Ohio. (Secretariat, Center for Documentation and Communication Research, Western Reserve Univ., Cleveland 6.)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable, and it reflects the claims of the manufacturer or other source. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 182.*

■ VACUUM-TUBE VOLTMETER displays on two separate meters the r.m.s. values of both in-phase and quadrature components of input signal voltage with respect to a given sine wave reference voltage of the frequency. Frequency range is 20 cy to 20 kcy/sec. Voltage ranges are 15 mv to 20 v for the reference and 15 mv to 15 v for the signal. Input impedance is greater than 50 megohm in parallel with 13 pf. Accuracy of ±2 percent of full scale is claimed. (Solartron, Inc., Dept. 922)

■ PULSE GENERATOR delivers evenly spaced pulses of positive or negative polarity. A mercury relay is used to obtain fast rise and exponential decay approximating those produced by radiation detectors. Output is adjustable from 1 μv to 10 v by means of a ten-turn potentiometer. Dimensions are 7 by 8 by 10 in. (Atomic Accessories, Inc., Dept. 929)

■ PHOTOELECTRIC TAPE READER accepts five-, six-, or seven-channel numeric tape for computer input. Speed of operation is 400 characters per second. Starting and stopping are effected on one character. No reels are used to carry rolls of tape up to 500 ft in length. A winder keeps the tape neatly rolled at all times. (Bendix Computer Division, Dept. 930)

■ VIBRATION RECORDER is a hand-held instrument for recording vibration amplitudes of machinery. The device is available with either ink or waxed-paper recording. The record is produced on 1-in. wide tape 350 ft long. Magnification is adjustable from 2 to 20 times. Frequency range is 0 to 20,000 cy/min, and amplitude range is 0.0004 to 0.800 in. Tape speed is 70 to 275 in./min, and running time is 6½ to 4½ min. Weight is 4¾ lb. (Korfand Co., Dept. 928)

■ RECORDER - CONTROLLERS of circular-chart type are equipped with either electric or pneumatic controls. All models include a constant-voltage supply that eliminates batteries, standard cells, and standardizing mechanism. Accuracy is ±0.25 percent of full scale or ±0.25 mv. Full-scale pen travel is 4⅜ in. with 5, 10, and 20 sec response time. Chart diameter is 12 in. Standard chart speeds range from 1 hr to 7 days/rev. (Daystrom, Inc., Dept. 935)

JOSHUA STERN
National Bureau of Standards
Washington, D.C.

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